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ELEVENTH SESSION

MADRID : 5-15 MAY 1930

GENERAL PROCEEDINGS

5th Section : Light railways and colonial railways.

INAUGURAL MEETING

6 May 1930, at 9 a. m.

Provisional Chairman : Mr. F. FIORI,
Member of the Permanent Commission of the Association.

The Chairman (in French). — The Permanent Commission has requested me to proceed to the inauguration of the 5th Section and the nomination of its officers. It has directed me to propose for your approval, as Sectional President, Dr. **Antonio Crispo**, Inspecteur général des chemins de fer, tramways et automobiles au Ministère des Communications, Italy, or, in his absence, **Mr. Biraghi**, Ingénieur, conseiller technique à la Confederazione nazionale fascista dei trasporti terrestri e della navigazione interna.

I feel sure that the Permanent Commission has made a very judicious choice and that the discussions will be conducted under most competent guidance (*Applause*).

In the name of the Permanent Commission I further propose the nomination, as Principal Secretaries, of **Mr. Allard**, Directeur de la traction et du matériel à la Société Nationale belge des chemins de fer vicinaux, and **Mr. Hennig**, Ingénieur à la Société Nationale des chemins de fer belges. (*Applause.*)

— Mr. Fiori then vacated the Chair in favour of Dr. Crispo.

— **Messrs. Crispo, Allard** and **Hennig** then took over their duties.

The President (in French). — Gentlemen and Colleagues, permit me first of all to express to you my gratitude for the honour of being elected to preside over the 5th Section of the Congress. This honour is, I know, paid not so much to me personally as to the country which I represent at this important international gathering. I shall do my best to ensure that our labours are as interesting and useful as possible, as regards both the economic and the technical questions which we are called upon to consider. I am sure that I can count upon the assistance of all my collaborators and upon the goodwill of all my colleagues to facilitate the execution of the task which has been entrusted to me. (*Applause.*)

We will now proceed to the nomination of the vice-presidents and secretaries.

The following are proposed as vice-president :

Messrs. L. Jacobs, directeur général-adjoint de la Société Nationale des Chemins de fer vicinaux, Belgium;

Yussef Risgallah Bey, sous-directeur général des Chemins de fer de l'Etat, Egypt;

O. Lagasse, directeur de la Compagnie des Chemins de fer Catalans, Spain; and

M. Gimenez Lombardo, directeur de la Compagnie des Chemins de fer Andalous, Spain. (*Applause.*)

— The Section then completed the Secretariat and drew up a provisional agenda.

QUESTION XVII.

PENETRATION RAILWAYS.

Construction :

a) *Penetration railways in new countries;*

b) *Feeder railways in all countries.*

Preliminary documents.

1st report (all countries, except those hereafter), by Mr. E. Mellini. (See *Bulletin*, November 1929, p. 2657 or separate issue No. 40.)

2nd report (America, the British Empire, China and Japan), by Sir Ashley Biggs and Mr. C. W. Lloyd Jones. (See *Bulletin*, August 1929, p. 1487 or separate issue No. 18.)

3rd report (Belgium, France, Holland, Portugal, Spain and their Colonies), by Mr. Pierre Jourdain. (See *Bulletin*, December 1929, p. 2925 or separate issue No. 44.)

Special Reporter: Mr. P. Jourdain. (See *Bulletin*, May 1930, p. 1536.)

DISCUSSION BY THE SECTION.

Meeting held on the 6 May 1930 (morning).

President : Dr. A. CRISPO.

The Meeting opens at 9.30 a. m.

The President. — We are to consider to-day Question XVII. I call upon Mr. Jourdain, *Special Reporter.*

Mr. Jourdain (in French). — Mr. President, Gentlemen, under the wording of Question XVII we have in fact two questions to consider : first, that of penetration railways and, secondly, that of feeder railways in all countries. I think that we can rapidly survey the question of penetration railways and discuss it, for it is quite distinct from the second. Messrs. Biggs and Lloyd Jones have not dealt with them separately because, in the countries in which they were specially interested, it appears that the penetration railways are not very distinct from the feeder railways. On the other hand, Mr. Mellini and I have treated the two questions separately. I will not press

the point. I think that all our colleagues have been able to read our reports on the data collected by us. We regret that we did not receive a larger number of replies, but we did collect some very interesting information with regard to the equipment which is used in new countries. I would therefore request you to refer to our reports, in which we have included a certain number of particulary interesting plans of locomotives, carriages and wagons.

We asked, first of all, what were the rules to be followed for the construction of penetration railways and, in the replies which we received, emphasis has been laid on this point : speaking generally, in the early days sufficient preliminary study was perhaps not given to the resources of the country in which it was proposed to construct new lines, or to the centres of population to be served, and it is recommended that in future a more detailed study be made of the region which it is proposed to serve before embarking upon the construction of a penetration railway. This defect is reported upon particularly in the case of Africa. Although it is above all to the probable goods traffic that one must look for positive results in the case of these lines, the fact must not be overlooked that, if the riches of a country are to be exploited, labour must be available, and, consequently, that the more important centres of population must be served. We endeavoured to ascertain whether any particulary interesting methods have been adopted in the construction of these lines, but there is little to report in this respect. It seems that, in general, the constructors of penetration railways have been guided by what was the practice in the mother country, not only as regards methods of construction but also as regards rolling stock, the permanent way superstructure and the choice of gauge, etc. And here we come to what is perhaps the most delicate point dealt with in our reports, a point which has given rise to a very large number of remarks and which will form a very interesting subject for discussion. You will doubtless remember (I have referred to it in my special report) the discussion which took place in London on this subject, and we can take up the discussion from that point.

Mr. Mellini recalls in his report that the following summary was arrived at :

From the technical and commercial points of view it is desirable that, in neighbouring countries, the main and secondary pioneer lines should adopt the same characteristics for equipment and rolling stock.

Messrs. Biggs and Lloyd Jones have also insisted upon the necessity for this.

As all the more important penetration railway companies are represented here, perhaps we can now have a discussion upon this point.

Messrs. Biggs and Lloyd Jones report that in India the greatest inconvenience has been experienced as a result of the existence of different gauges.

In Africa there are to-day six types of track, ranging from 0.61 m. to 1.45 m. (2 feet to 4 ft. 9 in.), the predominating gauges being 1 m. and 1.067 m. (3 ft. 3 3/8 in. and 3 ft. 6 in.). The 0.60 m. (1 ft.-11 5/8 in.) lines formerly used in Morocco and the Belgian Congo are almost all abandoned, as their capacity was inadequate.

The French colonies of Equatorial Africa have adopted a uniform gauge of 1 metre, and a large part of the Algerian

and Tunisian railways have done the same. The English, Portuguese and Belgian (Congo) railway systems are equipped with the 1.067-m. (3 ft.-6 in.) gauge. The types of rolling stock which are to be found on these railways are really remarkable and I have, in particular, drawn attention to the perfection of the rolling stock which has been introduced by the Compagnie belge des Chemins de fer du Congo supérieur aux Grands Lacs Africains. It appears that this railway is entirely satisfied with the 1.067-m. (3 ft.-6 in.) gauge. It is able to transport very large loads at quite adequate speeds.

On the other hand, in French North Africa there appears to be a tendency to get away from the use of the metre and 1.06-m. gauges, and certain authorities consider it imperative to adopt the 1.45-m. (4 ft.-9 in.) gauge for heavy traffic. Here, however, a difficulty will arise from which the light railways in France have suffered enormously : I refer to the linking up of metre-gauge lines with 1.45-m. lines, and to the charges entailed by transhipment.

I think it would be interesting to have the views of our colleagues now present upon this question, and I shall be glad if they will put forward their arguments in one sense or the other. We shall then be able to arrive at a conclusion in regard to this point.

Mr. Lloyd Jones, *Reporter*. — I have little to add to the report that has been ably discussed by Mr. Jourdain. Sir Ashley Biggs and myself have been impressed by the need for discussing the relative value of railways and road systems for developing new territory. It requires emphasis that the justification for the construction of a railway does not always depend on the ability to pay interest on the capital out of the net receipts from the traffic. When this has not been appreciated there has sometimes been a tendency to prejudice the usefulness and eventual success of a new railway system by attempts to make the railways immediately remunerative, particularly when this policy has resulted in the selection of an unsuitable gauge. A discussion of the gauge policy of penetration railways should be of considerable interest.

Mr. Watson, London & North Eastern Railway. — My experience in connection with two English light railways has shewn the disadvantages of having to have a change of gauge. I am of the opinion that if a light railway carries a sufficiently large proportion of traffic which has to be exchanged with a standard gauge railway, it is more economical and more satisfactory to the customers that the light railway should have the same gauge as the standard railway. In my experience it has not been possible to reduce the cost of transhipment between light railway and standard gauge below about two shillings per ton.

I consider that Section V might usefully record the opinion that, in connection with the question of gauge, a very important factor is the proportion of traffic requiring transhipment, and that, if this proportion is high, it constitutes a strong argument in favour of building the light railway to standard gauge, even though this involves a greater initial capital outlay.

Mr. Mellini, *Reporter* (in French). — I would like to be allowed to add a few words to the remarks of Mr. Jourdain on the situation of penetration railways,

with regard to the Italian colonies. Italy was among the last of the colonising countries and, from this point of view, may be said to have found herself in a favourable situation, as she has been able to study communication problems with full knowledge of what other countries have done, both as regards railways and other means of communication.

Mr. Jourdain has said that there are, in Africa for example, two gauges in more general use, namely the 1.067-m. gauge, which I will call the English gauge, and the metre gauge, the French gauge. In our colonies we have neither the 1.067-m. nor the metre gauge, but the 95-cm. (3 ft.-3 1/8 in.) gauge. Why have we adopted this gauge ? The question has been studied most minutely. We have, in Southern Italy, in Sicily and in Sardinia a gauge of 95 cm. for all the light railways. As those of our colonies on the shores of the Mediterranean give rise to a very important and rapid traffic exchange with the mother country, we have chosen the same gauge, not only with a view to the possibility of transporting rolling stock from Sicily or Sardinia to Africa, but also for ensuring unification of rail and rolling stock. We have not, however, overlooked the question of communication with the countries adjacent to our colonies, as for example Tunis and Egypt. In this connection we have in general found it prerable to organise autocar services for tourist traffic in North Africa. The present-day tourist prefers, in fact, to travel by autocar, whether for greater speed, or for facility of access to the various attractions of the country visited, or for other reasons.

As regards the transport of goods, the greater part of the goods produced in the colonies, or imported by them, pass through the ports. Thus, while the question of communication between the colonies is important, it is not a question of supreme interest. It is for this reason that we have retained the 95-cm. (3 ft. 3 1/8-in.) gauge, which we regard as very suitable for our purpose. If, therefore, we speak of unification of the type of gauge in each colony, we find ourselves in a favourable position. If, on the other hand, we speak of communication between the colonies of different countries, we do indeed experience certain difficulties, though they are, after all, difficulties of a secondary nature, in view of the fact that the greater part of the communications are provided by autocar service or through a port.

I wished to bring out this point, as Mr. Jourdain has not had occasion to refer to it. He has spoken only of the French and English gauges : I have referred to the question of gauge as it concerns Italy in particular.

Mr. Jacobs, *Vice-President* (In French). — I would like to be allowed to give a few details with regard to the gauges adopted in Belgium.

I hasten to say that I am in entire agreement with what Mr. Mellini has just said. When it is a question of local transport within any given country, it matters little whether one or the other gauge is adopted, provided the gauge chosen adequately meets the transport requirements. When, however, it is a question of international transport, or even of transport from continent to continent, it is important that, so far as possible, a uniform gauge be adopted everywhere. In the Belgian Congo there are two gauges — three, even. The line from Matadi to Léopoldville, which ori-

ginally had the 0.60-m. (1 ft.-11 5/8 in.) gauge, is at present in course of alteration, the new gauge being 1.067 m. (3 ft. 6 in.). All the railways of the Belgian Congo will have the same gauge; the 1.067-m. gauge will also be adopted for the projected railway from the Nile to the Belgian Congo.

Thus, from North to Central Africa, and even to South Africa, there will be the same gauge. It is to be regretted that the French have adopted the metre gauge in the French Congo.

With a view to diminishing as far as possible the inconvenience of differences of gauge, it is proposed to provide trains with wheels of variable gauge.

In Holland, trials have been made with wagons fitted with wheels of variable gauge, running at up to 60 km. (37.3 miles) per hour, but the results have not been very satisfactory.

It is certain that it would be preferable to adopt the same gauge everywhere, wheter it be 1.435 m., 1.067 m. or 1 m. In the Dutch East Indies, passenger trains attain speeds of more than 100 km. (62 miles), with absolute safety, on lines of 1.067-m. (3 ft.-6 in.) gauge.

For goods trains, the two gauges are equally satisfactory.

If it is desirable to have a uniform gauge in the colonies, this is even more desirable in the mother country. In Belgium, the Société Nationale des chemins de fer Vicinaux (National Light Railway Company) had three gauges, including the 1.067-m. (3 ft.-6 in.) gauge of the lines of the light railways in the province of Antwerp. The remainder of the light railway system, covering about 4 200 km. (2 610 miles), has the 1-m. or the 1.435-m. (3 ft.-3 3/8 in. or 4 ft.-8 1/2 in.) gauge. The 1.067-m. gauge was adopted over a length of 600 km. (373 miles), because the lines in question linked up with the Dutch lines, which had the 1.067-m. gauge. It has been found preferable to abandon the 1.067-m. gauge and to replace it by the metre gauge, which is the gauge of the whole of the light railway system with the exception of 38 km. (23.6 miles) which have the 1.435-m. gauge. The S. N. C. V. (Belgian National Light Railway Company) and the Société Nationale des chemins de fer belges (Belgian National Railway Company) have a length of line of about 5 000 km. (3 100 miles) each, or a total of about 10 000 km. (6 200 miles). It is to be regretted that the two systems have not the same gauge, as this would avoid enormous transhipment costs. In order to provide a partial remedy for the inconveniences of transhipment, use is made of transhipping trucks; the results so far obtained with these trucks are very satisfactory.

Mr. **J. F. de Sousa**, Ministry of Commerce and Communications, Portugal (in French). — In my capacity as delegate of the Portuguese Government, although I belong to a railway company in Portugal itself, I think that it may be useful for me to give some information in regard to our colonial railways. We are now grappling with difficulties which result from an initial error in the choice of gauge. We have, in the first place, in our Indian colony of Goa, a railway with the same gauge as the neighbouring English lines with which that railway is linked up. In our African colony, Mozambique, the gauge is 1.067 m. (3 ft. 6 in.) and the lines there link up with the South African railway system. In these cases, therefore, I have no comments to make.

In our colony of Angola, on the other hand, we have three different gauges. A start was made by adopting the gauge in use on the light railways in Portugal, viz. 1 m. (3 ft. 3 3/8 in.), for the penetration railway from Loanda to Malange, which has a length of 500 km. (310 miles). Later, when the important Benguela line, running from the port of Lobito to the Katanga and linking up with the lines of the Belgian Congo, was projected, the gauge selected was 1.067 m. (3 ft. 6 in.). This line is intended to carry to the port of Lobito, which will be suitably equipped, the traffic coming from the Katanga region. It ends in Portuguese territory and covers approximately 1 300 km. (808 miles). A third penetration line has been built, starting from the port of Mossamedès, with a gauge of 0.60 m. (1 ft. 11 5/8 in.). The construction of a fourth line is contemplated, to serve a river port on the River Congo. It is now realised that several transverse lines are also required and, further, that arrangements must be entered into with the Railways of the Belgian Congo.

We have, then, one important line of 1.067-m. gauge and another of 1-m. gauge which, owing to the difference of gauge, cannot join up with the first line. I think that the 1-m. gauge line will have to be widened. The Benguela railway line, which starts at Lobito, gives full satisfaction from the point of view of traffic requirements. It has powerful engines, carries heavy loads, and is destined to become one of the main arteries of Africa. When the 1-m. line has been widened we shall have an entirely satisfactory railway system which will work in co-operation with the road transport system. The desirability of adopting a uniform gauge of 1.067 m. for new lines has thus been recognised.

I would also like to say a few works about the inconvenience which has resulted from the variety of gauges in Portugal itself. We began with the 1.44-m. (4 ft.-8 3/4 in.) gauge, then, as Spain had adopted the 1.67-m. (5 ft.-5 3/4 in.) gauge, we widened our gauge on 130 km. (81 miles) then in operation, so as to have the latter gauge on all our lines. As the northern part of the country is very hilly, we were forced to the conclusion that a smaller gauge was essential for our light railways, and we accordingly adopted the metre gauge. We have 668 km. (415 miles of metre gauge and 2 743 km. (1 074 miles) of broad gauge. We had, further, a line with 0.90-m. (2 ft.-11 1/2 in.) gauge which has recently been widened. To summarise, we have two types of line, but although there are the inconveniences of transhipment, the economies effected by the use of the narrow gauge in the northern part of the country are very considerable.

Mr. Lagasse, *Vice-President.* — I think it would be most interesting to hear the views of the representatives of the French railways of Africa upon the respective advantages of the 1-m. and the 1.067-m. gauges, there being practically no difference between the two measurements. Many companies prefer the 1.067-m. line on the ground that it gives greater stability. Personally I can say that our experience of the 1-m. gauge has been entirely satisfactory. At high speeds, however, e. g. at 70 km. (43.5 miles) per hour, we have found that there is an excessive strain on the line. We should be very glad to have information on the subject of the behaviour of both the 1.067-m. and the 1-m. track.

Mr. Jourdain (in French). — I will first of all reply to the remarks made by Mr. Lloyd Jones at the commencement of our discussion. I apologise for not having spoken in my report of the question put forward at the beginning of our reports, namely : in the present state of things, what is the best means of penetration into a new country, the railway, or the motor road ?

Everybody is unanimous in saying that, if a country is to be efficiently developed, it is the railway which is necessary, but it is evident on the other hand that, in new countries, the motor road must play a considerable role. As has been said by Mr. Mellini, it is certain that as time goes on we shall have to resort more and more to the automobile for rapid tourist services. The railway is suited rather to the economic development of the country than to the development of tourist traffic. The second point referred to by Mr. Lloyd Jones was the question of what is to be looked for from a penetration railway. Is the first point to be considered its working and financial results ? I think that the replies which we have received on this point are practically unanimous. In a country which is undergoing the process of colonisation this question is of rather secondary importance, and it is necessary that the central Government or the colony itself should defray the necessary expenses. Whether the railway itself will be remunerative or not is a question, as I have said, of secondary importance.

I now come to the third question, which has given rise to considerable discussion and comment. According to the remarks made by Mr. de Sousa, in particular the Portuguese colonies had equipped a certain number of their lines with 1-m. gauge, and they are at present considering the standardisation of gauge at 1.067 m. This is interesting, as is also the statement just made by Mr. Jacobs to the effect that the important line from the Cape to Cairo is to have the 1.067-m. (3 ft.-6 in.) gauge.

The question arises : what gauge is to be adopted for the Trans-Sahara railway, which has to be linked up with the pre-existing lines ?

Have either the 1-m. or the 1.067-m. gauge an advantage over the other, from the point of view of stability? I do not consider this to be a point of great importance. We have metre gauge lines on which we run at speeds of 70 km. (43.5 miles) per hour. Do you not consider that the main consideration in this connection is the method of construction of the track and the weight of the rails ? I am convinced that there is practically no difference between the 1-m. and the 1.067-m. gauges from the point of view of stability.

Mr. Jacobs has just asked : Would it not be possible to contemplate the possibility, at some given future moment, of the unification of the 1-m. or 1.067-m. lines in Africa, so as to be able to utilise the 1.067-m. lines for rolling stock run on 1-m. lines ? I think that, particularly at high speeds, there might be certain objections to this, but it seems to me that if there were a real desire to unify the gauges of the African lines, this would not be impossible. The French railways of Africa might perhaps contemplate the increasing of their gauge from 1 m. to 1.02 m., or to 1.03 m. (from 3 ft. 3 3/8 in. to 3 ft. 4 5/32 in., or to 3 ft. 4 9/10 in.). In this connection I may refer to the position in France, where we have different gauges. We have not the 1-m. throughout and, in particular, we have tyre gauges varying

from 920 to 950 mm. (3 ft. 1/4 in. to 3 ft. 1 1/4 in.), i. e. a margin of 30 mm. (1 3/16 inch.). We have, without any inconvenience, been able to run both 920-mm. and 950-mm. rolling stock on the 1-m. gauge lines. All that is necessary is to have rails with sufficient clearance. It would be possible to unify the gauge of lines in Africa in, say, two stages, thus making it possible to link up the railways of French gauge with the railways of Egypt, the Portuguese colonies and British Africa.

In my opinion, however, it is very difficult at this stage to formulate definite conclusions on this subject.

Mr. Lisboa de Lima, State Railways of the Portuguese Colonies (in French). — In my capacity as delegate of the railways of the Portuguese colonies, this question of the gauge for colonial railways is of very great interest to me. The Portuguese Government is about to send five missions to Angola, three of them to examine the question of the railways generally, and one to study the possible improvement of roads, with a view to the linking up of the network of roads with the penetration railways running from the north to the south of the colony of Angola, that is to say, the Loanda railway, which has now a length of 500 km. (310 miles), the railway to the port of Mossamedès, 220 km. (137 miles), and the Benguela railway, 1 300 km. (808 miles). These missions will also study the project for a new railway starting from the Congo river, which railway will have a length of approximately 300 km. (186 miles).

You are familiar with the geographical situation of the large Portuguese colonies in Africa—Angola and Mozambique. The normal gauge adopted by all the railways of our colonies should be 1.067 m. (3 ft. 6 in.), as these penetration railways are intended to be linked up later with the railway systems of Central Africa. You are doubtless aware that the linking up of the Lobito Bay railway with the Katanga railway has just been completed. We still have in the colonies lines with the 0.60-m. (1 ft.-11 5/8 in.) gauge, and even 0.75 m. (2 ft. 5 1/2 in.), but, in my opinion, they are only of a provisional nature. The line which starts at Beira had at the beginning a gauge of 0.60 m.; it was subsequently realised that a modification was necessary, and it was increased to 1.067 m. We are proposing to lengthen the Mozambique railway, which runs from the port to the interior of the country, and which will also have the 1.067-m. gauge.

In Angola there is also the Amboin railway — about 100 km. (62 miles) — with the 0.60-m. gauge.

To summarise, this question of gauge is for us of great importance, but I am convinced that, for new lines, with the exception of local lines the problem will be solved by means of unification.

Mr. Gilles Cardin, Ministry of Public Works, France (in French). — Mr. Jourdain has asked me to give some details with regard to the Trans-Sahara railway. I have been engaged upon the question of that railway since 1922. At the end of 1923 I was sent on a mission to the Sahara by the Minister of Public Works, to study the Algerian end of the railway. More recently I was a member of the committee formed in 1928 to control the Trans-Sahara survey service. For a long time past the adoption for this line of the normal French gauge (1.45 m. = 4 ft. 9 in.) has been contemplated, and at the beginning of this year the survey

commission pronounced most strongly in favour of this gauge. Obviously, the linking up with the colonial lines of French West Africa will entail some difficulties; nevertheless, as the normal French gauge possesses many advantages for the Trans-Sahara railway, we have not hesitated to adopt it.

Mr. Van Noorbeeck, Belgian National Light Railway Company (in French). — The Special Reporter has just said that it was difficult to formulate any definite opinion upon the question of gauge. I think, however, that we might now conclude our discussion of this point. The conclusion that appears to emerge from the different points of view that have been expressed is that the question of gauge is one of circumstances, depending in particular on considerations of a financial and economic nature. In my opinion we can, however, lay down a general principle. We are all, I think, agreed that in each country penetration railways and light railways should in general have the same gauge. I propose, therefore, that we wind up our discussion by an expression of opinion to this effect.

Mr. Mellini (in French). — I support the proposal which has just been made. We might express the desirability of arranging for the running of trains over lines of different gauges, but I do not think that this solution would be entirely satisfactory, and it would in any case make running at high speeds impossible. It seems, therefore, that this solution must be excluded, and I prefer that which has been put forward by Mr. Van Noorbeeck : it is preferable to unify gauges in each country and in each colony.

I venture to add one more remark with reference to what has been said by our worthy Vice-President concerning the lines of communication between Cairo and the Cape. The line from the Cape to Cairo will represent a magnificent achievement and will do honour to the engineers who have planned and carried it to completion, but I believe that in the future communication between these two points will be effected largely by means of the aeroplane.

For the rest, I am entirely in agreement with the conclusion which Mr. Van Noorbeeck has just proposed.

The President (in French). — As no one has any further remarks to make, we will regard the discussion on the first part of Question XVII as closed.

I will ask Mr. Van Noorbeeck to put into writing the proposition which he has just made.

We now come to the second part of the question : *Feeder railways in all countries.*

I call upon Mr. Jourdain, *Special Reporter.*

Mr. Jourdain (in French). — I do not think it is absolutely necessary to give a summary of the three reports submitted on the second part of Question XVII. In my special report I have summarised the more important information supplied to us from the various sources. In Europe feeder railways have for several years been passing through an exceedingly grave crisis. This crisis is due in the first place to the changes which have taken place in the general economic situation, it not having always been possible to adapt rates sufficiently rapidly to the fluctuations which have taken place in currency values in the various countries. The consequences so far as

the railways are concerned have been most serious.

The crisis has, however, other causes, and the principal cause, which is particularly emphasized in the reports, is the development of motor traction and the effect of this new form of competition upon our light railways, which suffer from it in a number of respects. In general, it may be said that these lines, the lay-out of which is indeed far from ideal and which zigzag about from village to village, are not noted for their speed. The gradients of the lines are such that their operating costs are very high. On certain railway systems in France we have followed the policy which has been adopted by the Belgian light railways. We have also laid many lines alongside the roads. This was obviously the best course to adopt in so flat a region as Belgian Flanders, and was in no way detrimental to the lay-out of the lines or, consequently, to traction, but showed itself to be distinctly unfavourable in other more undulating districts. Many of these railways, as the result of the development of motor transport, have found themselves in an obviously bad position. The consequence has been that those lines which were the least remunerative before 1914, have since the war lost practically the whole of their traffic. In many countries, in France in particular, it has been necessary to contemplate the necessity of closing down a large number of lines, retaining only those which have sufficient traffic to keep them alive. As regard the construction of new lines, the number of new lines projected in the whole of Europe, with the exception of Spain, is excessively small. Mr. Mellini considers that a new railway should not be built unless the anticipated traffic is sufficient to produce receipts of at least 50 000 lire per kilometre (80 000 lire per mile). This standard is somewhat high, but it is evident that it would not be reasonable to build a railway at the present day unless it could count on receipts approaching this level.

I have summarised as follows the conclusions which we think we may formulate and which, if you are in agreement, we can now discuss :

In brief, in order to remedy the present position of the feeder railways, the line of action should lead us to :

1. Close down those lines the receipts of which are insufficient and result in considerable operating deficit, and replace them by road motor services.

2. Improve the operating conditions of the other lines by following the guiding lines given above.

3. Take over or control the road motor services acting as feeders to or competing with the light railways.

In France we have taken considerable steps in this direction during the last three years, and we think that this policy will afford us effective protection. Our desire is that in any given « Département » the road motor services and the light railway systems should pass into the same hands.

Mr. J. F. de Sousa (in French).— This question of feeder lines and the difficulties experienced at the present time in connection therewith, is a subject of particular importance in the case of Portugal. Two years ago the Government nominated a commission, of which I was appointed secretary, to carry out an administrative inquiry into this subject and, on the basis of the data collected, to draw up a general public utility

scheme. In the elaboration of this scheme we encountered considerable difficulties, as the railway system was just at that time feeling the effects of road motor transport competition. Certain engineers were of the opinion that it was necessary to give way to the new method of transport — the road motor service — and to cease sinking capital in the construction of railways.

In reasoning thus two considerations were overlooked : the first is that our railway system has a total length of scarcely 3 400 km., and we badly require many new lines. We have, for example, in the great Douro valley, one main broad gauge line and four narrow gauge feeder lines. There is no intercommunication between the latter lines and, therefore, rolling stock cannot pass from one line to another.

Further, there is always a readiness to incur expense on the construction of roads, the cost of maintaining these being borne by the Government, whereas the railways are required to meet the whole of their own costs.

I consider that where the public interest is concerned, a generous policy should be adopted. In our proposal, schemes have been drawn up for the construction of about 3 000 km. (1 864 miles) of line, to assist the economic development of the country. All these will be feeder lines.

As regards the question of motor transport competition, this is being seriously considered at the present moment, and I believe that the Portuguese Government is on the eve of taking the necessary measures and will introduce an effective scheme of taxation. The transport tax will be imposed on motor transport, and the operating conditions of feeder lines will be regulated in such a way that, as far as possible, motor transport will collaborate rather than compete with the railways.

I think, therefore, that the question must be approached with considerable caution. I also think that we must not think only of the return on capital. The railway is an instrument of national economic development and must satisfy the actual economic requirements of the country. If the Treasury is willing to make sacrifices for the roads, it must do the same for the railways, the utility of which is beyond question.

Mr. Biraghi, Confederazione nazionale fascista dei trasporti terrestri e della navigazione interna, Italy (in French).— I think that it is above all essential to examine the question from two points of view : that of the future and that of the present. As regards the future, I am in agreement with Mr. Mellini : when the construction of a light railway is projected, consideration must be given in the first place to the estimated amount of traffic that the line will carry. As regards the present, the situation is more complicated in view of the crisis through which a number of the light railways are passing resulting from the war, currency fluctuations and, also, competition.

In his summary the Special Reporter proposes the adoption of the following recommendation :

1. To close down those lines the receipts of which are insufficient and result in considerable operating deficit, and replace them by road motor services.

This solution appears to me to be too radical, particularly when one looks at the question from the point of view of the national equipment.

If the lines to be closed down belong

to the State, the fact of closing them down does not cause the same complications as would be the case with private lines in which a large amount of capital had been invested. In my opinion, we must contemplate all the consequences of closing down, particularly from the point of view of the national equipment.

Most of us represent private companies, but our mission is to serve the public. Take, for example, the case of a feeder line which, starting from a main line of national or international importance, runs thence into a side valley, where it may extend ten, twenty, or even a hundred kilometres. It sets out from a point where traffic is intense, and runs out to the far distant point where the tributary stream of traffic has its source. If you close down such a line, you immediately suppress an important source of traffic; a number of road motor services will spring up to serve the public, while small isolated centres of populations in the mountains will be deprived of every means of transport. You will thus abandon a wide district and deprive its inhabitants of the possibility of sending their products down to the main railway. Even in the vicinity of the main line, the more expensive class of goods will be transported and the poorer products will be neglected. Agriculture will be unable to dispose of its produce because it will not be able to pay the high costs of motor transport. The question is, thus, far from simple. We have a public service to perform and we have not the right, merely for financial reasons, to sacrifice communities situated far away from the main railways.

As Mr. de Sousa has said, the Government which, in order to develop industry based on the natural resources of a country, expends enormous sums on its road system, has no right to destroy its inheritance, the railway, built by the sacrifices of our fathers ! I think, therefore, that we should consider this question from a much broader point of view than that suggested in point 1 of the proposed recommendations.

On the other hand, I willingly agree to point 2, concerning the improvement of the operating conditions of our other lines, at the same time pointing out that it is not at a time of crisis — railway crisis, export crisis, financial crisis in general — like the present, that private capital can be expected to interest itself to so great an extent in our undertakings. It is for the public authorities to intervene in order to save the country's railway equipment.

I now come to the third point of the recommendations, which is : « To take over or control the road motor services acting as feeders to or competing with the light railways. » It seems to me that this is only begging the question. What do we mean by : « taking over », unless it be « strangling » the road motor services or preventing the running of any competitive services ?

What must in my opinion be done is to say to the Government : « Why are the railways subjected to such heavy taxation, while the road motor services escape this ? As regards the taxation that should be imposed on the railways and on motor services, the relative conditions are not comparable. The railways have to bear very high maintenance charges, whereas, in the case of motor transport, the roads and their maintenance are furnished by the State. The motor transport services must therefore be asked to reimburse you for this part of the costs which, in the case of the railways, are borne by the companies. »

I would suggest, therefore, that we look at the question from a broader point of view than is reflected in the suggested conclusions.

Mr. Jourdain (in French). — I would like to say a few words in reply to Mr. Biraghi's criticisms of our report and, in particular, upon two points which appear to me to be important. In the first place, he reproaches us for sacrificing too readily an equipment which is not only that of our own industry, but at the same time a national equipment, and, by so doing, sacrificing certain centres of population who deserve to be treated a little less severely than we apparently propose. He adds that the Governments must intervene.

We are industrialists, and it is essential that we balance our budget of receipts and expenditure. It is certain that we have in our hands a national equipment, which is valuable not only to us but to the country as a whole. Thus, when we contemplate the closing down of certain lines, as we are doing in France, it is in agreement with the Government or with the « Département », and we do not close down these lines unless or until their traffic has become negligible. We have lines which transport an average of from 10 to 20 tons of goods per day, with receipts of 1 000 gold francs per kilometre (1 600 gold francs per mile), whereas motor transport services could carry all the passengers and goods at present carried by those lines. We cannot continue to maintain lines under these conditions, and we are replacing them by motor services. The population is, moreover, delighted at this state of things, and asks nothing better than that the system which collects or delivers goods at their door shall be continued.

I regret that we have perhaps summarised the question too briefly, and I see no objection to adding to the first paragraph : « unless the State or Provinces concerned will themselves take measures with a view to conserving the national equipment ».

In regard to point 3 : « Take over or control the road motor services acting as feeders to or competing with the light railways », Mr. Biraghi remarks : « The formula is simple : Do you, or do you not, wish to strangle motor transport ? » I expressed myself quite clearly, and there is no reason to dissimulate : we are seeking to revivify lines which are no longer alive.

Thus, we have certain lines installed alongside the roads. What are the motor proprietors of the country doing ? When they know that we have large numbers of passengers to transport, they take up their stand by the side of the train and offer to transport the passengers at rates which are no higher than ours and at a higher speed. Is not the best method of avoiding this competition to provide the motor transport ourselves ? I see no reason for dissimulation : I can state the case still more clearly if this is desired.

I would add that this question is to be discussed by the 4th Section. I think, however, that there is nothing compromising in the third paragraph. Is it necessary to make it more explicit ? I think not.

Mr. Jacobs (in French). — I propose the adoption of Mr. Jourdain's text just as it stands, as his conclusions appear to me to be such as can be accepted by the delegates of all the countries here represented.

The question raised by the Special Reporter is very complex and varies, one may say, from country to country.

Mr. Jourdain was so good as to say that France has followed the example of Belgium in laying down lines alongside the roads. I must, however, point out to him that the question affects Belgium in a quite different way. We have, of course, cases which are similar, but speaking generally the Belgian light railways do not resemble the French light railways. It is for this reason that the question now before us must be considered and decided according to the situation and particular interests of each individual country.

I propose the adoption of point 1 of the summary as originally drafted, subject to the addition of the new sentence which has been read out to us by Mr. Jourdain.

In this way everybody will be in a position to assume, vis-à-vis their own Government, the attitude which they think best.

In Belgium, the closing down of light railways is provided for under the following conditions :

1. If during three consecutive years the gross receipts of a line have been insufficient to cover operating expenses;

2. If during five consecutive years the net proceeds of a line have been insufficient to cover 50 % of the interest due on the capital invested.

I should like to say that point 3 of the summary fits in very well with point 1. Mr. Jourdain does not desire simply to close down the lines and to take no further thought for the transport facilities required by the districts hitherto served by the lines. He says, in point 3, that the railway company should take over motor transport to replace transport by rail. This is not expressed very clearly, but it is obviously understood. In Belgium the National Light Railway Company is at the present moment negotiating with the Government with this end in view. Certain light railways are earning practically nothing, and it is obviously better to sacrifice even an appreciable amount of capital rather than continue year after year to make losses, which can only increase as time goes on. Motor transport competition is such that soon not a single passenger will be left to the steam traction lines. The passengers have no further use for steam traction; they no longer wish to enter a steam driven train, which they find antiquated and not too comfortable, even when they are well looked after. Public preference is for the motor.

It is with a view to finding a remedy for the existing situation that the Belgian Minister of Transport has invited officials of the railway and tramway companies to accompany him to Holland to study the transport problem there.

When a motor-bus company asks for a concession for a route which might compete with a railway, the Dutch Government asks the railway company concerned to state what improvements it proposes to effect in its operating. If the company undertakes to modernise its methods of transport within a given space of time, or if it undertakes to provide motor-bus services to replace the existing mode of transport, the Government grants the concession to the railway company, on condition that its undertakings are met within the time stipulated. This is what we also are asking of the Belgian Government; it is the solution which appears the most logical and the most equitable.

If the motor transport services competed in a loyal manner, we should have nothing to complain of. But what actually does happen ? In general, the motor services are merely family undertakings. A father will work with two, three or more children (boys or girls); he buys two or three second-hand cars or buses, and the business is launched. They do not need to bother about the law which imposes an eight-hour day, as they do not come under it. Nor do they need to worry about the fiscal laws. They can work 15 or 20 hours a day if they wish. They turn up wherever there are festivities or ceremonies at which there is money to be earned. On Sundays they organise special services which take away the last remaining passengers from the steam traction line, which will rapidly decline.

We ask the Government that all services be put on the same footing, that is to say, that the man who organises a motor transport service should have the same obligations as the company which provides a railway service.

The Belgian National Light Railway Company further demands, in the general public interest, to be allowed to organise motor transport services itself, as it has facilities for the organisation of such services which a private company could not possess. These facilities are as follows :

The Belgian National Light Railway Company can operate the railways and the motor transport services under the same management and without additional general expenses.

Control of the motor services can be performed by the present line staff of the light railways.

The existing workshops can be equipped at very little cost for the upkeep of petrol motors. The steam locomotive sheds can be transformed into garages for the motor-buses.

The greatest advantage of all lies in the availability of a competent technical staff : workshop hands can be trained to act as motor-bus drivers, and can be used to supplement the regular staff of drivers during the morning and evening rush hours, on routes where this is necessary. During the daytime these supplementary drivers can be employed in the workshops on the upkeep of rolling stock

From what I have said it will be seen that we have not the least intention of « strangling » motor-bus services. It is for this reason that I support the adoption of point 3 of Mr. Jourdain's recommendations.

Mr. Biraghi calls for extensive support from the various governments for the modernisation of existing railway systems, under the pretext that it is not at a moment when we are working at a loss, and when the general economic situation is bad, that we should demand further sacrifices of the companies. These sacrifices, however, are inevitable. If we do not modify our systems the governments will say to us :

« Your services are inadequate; the public is demanding motor-buses, which are elements of progress which we cannot ignore. »

We must reply :

« We are ready to modernise our systems; we want to replace steam either by electricity or by petrol motors or by heavy oil motors or by motor-buses or by any other economic modern means of transport, which will be judiciously introduced according to the circumstances. »

I may mention that in Belgium we have used the Dielsel locomotive, the first occasion on which it has been used for the traction of passenger trains. It has only been in use for a month, but has given satisfaction up to the present.

Mr. Jourdain (in French). — I think that in order to give satisfaction to Mr. Biraghi we must at least add to the first paragraph the phrase which I read to you a few minutes ago.

Mr. Biraghi (in French). — I asked for an addition to the text proposed by Mr. Jourdain, an addition of a financial rather than of a technical nature. We have been told what has been done in France and in Belgium with regard to the Government. What I particularly desire is that the recommendation approved by our Congress should not be merely technical, but that it should emphasize the necessity for the intervention of the Governments in the different countries.

The President (in French). — Mr. Biraghi has perhaps been somewhat emphatic in his statements, but it must be remembered that in Italy the Government has already (in August 1929) passed a law which lays down that, in the case of old steam traction lines, or lines which have constructional defects or are no longer up to date, the Government may grant a subsidy to the operating companies to assist them to improve the lines and, if possible, to introduce the latest improvements. The subsidy takes the form of annual payments which, in the case of light railways (previously called tramways), may amount to as much as 12 000 lire per kilometre (19 200 lire per mile), over a period of 35 years, and in the case of other companies may amount to 20 000 lire per kilometre (32 000 lire per mile), over a period of 50 years. Thus, these companies, aided by the Government in this remarkable manner, are in a position to operate their lines under modern traffic conditions. If the lines are electrified the Government grants a supplementary subsidy of 10 000 lire per kilometre (16 000 lire per mile). Thus, an old steam traction line which is not only improved but electrified will receive a total subsidy at the rate of 30 000 lire per kilometre (48 000 lire per mile). It is, I think, the first time that a European Government has granted such generous assistance for the transformation of old lines, and thanks to this assistance it has been possible effectively to meet motor transport competition.

In Italy attempts have been made to close down old lines, which seemed to be a very simple solution. The Government wished to begin by closing down certain of the oldest lines, but protests were so numerous that the idea had to be dropped. Such was the case in Sicily, where an old line about 40 km. (25 miles) long was about to be closed down, owing to the lack of comfort for passengers, and replaced by a service of magnificent motor-buses and autocars, which would charge the same rates as the old railway line. In view of the public protests it was necessary to leave the old light railway in operation — of course with provision for greater comfort than in the past !

It is evident that account must also be taken of the financial situation of the country. It is not possible to do everything that everybody wants : changes can only be effected gradually.

Having given these explanations, I think that Mr. Jourdain's text may now

be adopted subject to slight modifications.

Mr. Jourdain (in French). — Before reading out the final text, I wish to remark that in France the Government is perfectly prepared to assist in the electrification of lines by assuming the responsibility for 50 % of the cost.

Mr. Marguerat, Viège-Zermatt Railway, Switzerland (in French). — I am in agreement, in general, with the propositions which have been put forward; but it appears to me that we ought to ask that the Government should tax undertakings which run motor services for public transport. There is no doubt whatever that, if the railways are passing through a time of crisis, the cause is to be found in the unfair competition of motor transport. In Switzerland we are suffering particularly from this state of affairs. Motor transport undertakings are not bound by the same severe rules, whether as regards working hours, or civic responsibilities (a most important consideration for the railways), or for the safeness of their vehicles, etc. For the railways, on the other hand, the rules and regulations are excessively severe.

It seems to me essential that we should press the authorities to submit public transport motor services, whether for the conveyance of passengers, luggage or goods, to the same taxation and regulations as are applied to the railways.

In a country like ours, we have to encounter this competition during the busy season; during this season traffic is very remunerative, and the roads are one long stream of motor-buses and autocars; but in winter, when we have to provide a service, with snow up to 5 feet deep, there is no longer any competition.

In this connection, I venture to revert to what Mr. Mellini has said in regard to motor transport competition.

We have the impression that the railways had gone to sleep and that, at the present day, they are waking up and are capable of withstanding motor transport competition. There is no doubt that given modern and comfortable rolling stock, we can meet that competition. We already have restaurant cars on narrow gauge lines; we are contemplating the introduction of Pullman cars, and there is no question but that one can travel much more comfortably in through-corridor trains (not to mention the additional advantage of lavatory accommodation) than in motor-buses. The railway will be able to retain its traffic, provided it can keep up with the times. In this connection I would like to say that, as regards motor competition, the question of service from door to door is very important. Several railway companies in Switzerland have adopted this service.

At the Congress held at Rome we realised that the situation was desperate. This is no longer the case to-day; we have the impression that the public is returning more and more to the railways. The question is quite different to-day from what it was at the time of the last Congress. We must, like commercial travellers, go out and seek the customer and his goods.

Mr. Mellini (in French). — I venture to point out to my Swiss Colleague, who has made some very interesting statements, that this is a question which is to be dealt with by the 4th Section. We cannot here make proposals or recommendations which, later, may be found to be in contradiction to the conclusions arrived at by that Section. I think, the-

refore, that we must refrain from discussing the question raised by Mr. Marguerat, leaving it for the consideration by the proper Section.

Mr. Jourdain (in French). — Would not the meeting prefer to ask that we be allowed to discuss the question of motor transport competition to-morrow jointly with the 3rd and 4th Sections, as we have already finished our consideration of Question XVII? (*Signs of approval.*)

In that case the final paragraph will be decided upon in agreement with the other two Sections.

Mr. Van Noorbeeck has proposed the following wording for the conclusion to the first part of Question XVII :

« It would appear from the remarks made during the discussion that it is desirable that there should be a uniform gauge for the penetration railways in each country. »

— Adopted.

The President (in French). — The wording proposed by Mr. Van Noorbeeck is approved.

The final summary relating to the second part of the question will be considered at our meeting on 8 May.

Mr. Jourdain (in French). — May I inform the meeting that the President of the 3rd Section has just stated that he agrees to our Section taking part in the discussion on the question of motor transport competition ?

The meeting then closed.

Meeting held on the 8 May 1930 (morning).

Mr. JACOBS, Vice-President, in the Chair.

The President. — We will now resume our discussion upon Question XVII. I will call upon Mr. van Leeuw.

Mr. Van Leeuw, Ministry for the Colonies, Belgium (in French).— Gentlemen, I regret that I was unable to be present at your first meeting. I have learnt that the view of the Section was that there should be a uniform gauge for the railways of each country. This conclusion is so logical that it is scarcely necessary to state it. In the Belgian Congo we have had reason to know the difficulties which may result from a lack of foresight at the commencement. Our colony is extremely large. Right from the beginning it had been decided to construct five railway lines, but owing to lack of coordination they were all given different gauges : the Mayumbé railway, 0.615 m (2 ft. 3/16 in.); the Congo railway, 0.765 m. (2 ft. 6 1/8 in.); the railway from the Congo to the Great African Lakes, 1 m. (3 ft. 3 3/8 in.); the Congo light railways, 0.60 m. (1 ft. 11 5/8 in.), and the Katanga railway, 1.067 m. (3 ft. 6 in.).

It was subsequently realised that it was essential to standardise these railways : henceforth our new lines will have either the 0.60-m. or the 1.067-m. gauge. The 1.067-m. (3 ft.-6 in.) gauge is the more desirable by reason of the connection our lines have with those of

British South Africa, which all have this gauge.

In Mr. Jourdain's report it is stated that in the Belgian Congo it has been decided to adopt the 0.60-m. gauge for the future. There is a slight error here. The 0.60-m. gauge has been adopted merely as a provisional measure, until such time as the traffic has attained a sufficient density, say from 50 000 to 60 000 tons, and, then, the 0.60-m. gauge will be replaced by the 1-m. gauge, which in turn will be converted into the 1.067-m. gauge, adopted as the standard gauge for the colony. For example, it has been decided to convert the gauge of the Great Lakes Railway from 1 m. to 1.067 m. Work has already been commenced and the new 1.067-m. gauge sleepers are being laid. By means of additional drilling, these sleepers can be used provisionally for the 1-m. gauge line.

It seems to me, however, that it is not sufficient to unify the gauge within one's own country, but that it is still more important to unify in collaboration with the neighbouring countries. For example, what is happening in Central Africa ? We have the 1.067-m. gauge line, to which we are committed. The French also propose to adopt this gauge for their line from Brazzaville to Pointe-Noire. On the other hand, in Uganda and in the former German colony of East Africa, the 1-m. gauge is in use. Uganda is an obvious point of departure for the regions of the North-Eastern Congo : but the English have the 1-m. gauge while we have the 1.067-m.

I consider, therefore, that we should give the proposed summary a somewhat more general scope by recommending unification of gauge not merely in each country but also within regions which form economic units.

Mr. Jourdain (in French). — In reply to Mr. Van Leeuw I would like to say that we considered the question the other day from the point of view which he has just put forward, and Mr. Van Noorbeek then added to his summary a paragraph covering the recommendation which Mr. Van Leeuw now desires to have made. I, in fact, requested a representative of French colonial Africa to give us his views upon the question before us, and Mr. Gilles-Cardin, who represents the Trans-Sahara railway, explained to us that after having carefully studied the question, the French Government and the colonies concerned favoured the 1.45-m. (4 ft.-9 in.) gauge, and that in fact they had actually decided upon its adoption. It was as a result of this information that we modified Mr. Van Noorbeeck's original wording, and I think it is difficult to go back now upon the decision taken.

The President. — I think that we should adhere to the summary adopted at the meeting held the day before yesterday, as regards the question of penetration railways. (*Signs of approval.*)

It now remains for us to adopt or to modify the summary presented to us as the outcome of the meeting held yesterday jointly with the 3rd and 4th Sections.

Mr. Jourdain has just handed me the text of this summary, which relates to part (*b*) of Question XVII, dealing with *feeder railways in all countries.* The text reads as follows :

Part *b*) :

« With a view to remedying the present situation of feeder railways, it is recommended :

« 1. hat, while respecting the rights

of capital invested, lines whose receipts are so inadequate that considerable deficits must result in the future, be closed down unless the State, Provinces or Towns concerned will themselves cover such deficits with a view to conserving the national equipment;

« 2. that lines closed down be replaced by motor services;

« 3. that the working conditions of the remaining lines be improved with the financial assistance of the State, Provinces, or Municipalities concerned;

« 4. as regards the attitude to be adopted towards road transport competition, the Section refers to the conclusions adopted in conjunction with Sections III and IV. »

The above summaries were adopted unanimously.

DISCUSSION AT THE GENERAL MEETING.

Meeting of the 10 May 1930 (morning).

PRESIDENT : MR. JOSÉ GAYTAN DE AYALA.
GENERAL SECRETARIES : MESSRS. P. GHILAIN AND A. KRAHE.
ASSISTANT GENERAL SECRETARIES : SIR HENRY FOWLER, K. B. E., MESSRS. P. WOLF AND J. M. GARCIA-LOMAS.

Mr. Ghilain, *General Secretary.* — Gentlemen, we will now deal with the summaries proposed, by the 5th Section, for Question XVII. However, before doing so, I wish to remind you that Question XVII is related to two distinct subjects :

a) Penetration railways in new countries, on one hand, and

b) Feeder railways in all countries, on the other.

Summaries have been drawn up for both parts and you have been able to take cognizance of them in the *Daily Journal of the Session.*

Are there any remarks with regard to these summaries ?

— Nobody wished to speak.

Mr. Ghilain. — In that case, the proposed wording may be considered as approved.

The President. — The final summaries are consequently as follows :

SUMMARIES.

Part *a*) :

« It would appear from the remarks « made during the discussion that it is « desirable that there should be a uniform gauge for the penetration railways in each country. »

Part *b*):

« With a view to remedying the present situation of feeder railways, it is « recommended :

« 1. that, while respecting the rights of « capital invested, lines whose receipts « are so inadequate that considerable deficits must result in the future, be closed down unless the State, Provinces or « Towns concerned will themselves cover « such deficits with a view to conserving « the national equipment;

« 2. that lines closed down be replaced « by motor services;

« 3. that the working conditions of the « remaining lines be improved with the « financial assistance of the State, Provinces, or Municipalities concerned;

« 4. as regards the attitude to be adopted towards road transport competition, « the Section refers to the conclusions « adopted in conjunction with Sections « III and IV. »

[625. 614]

QUESTION XVIII.

IMPROVEMENTS IN THE PERMANENT WAY EQUIPMENT OF LIGHT RAILWAYS.

Preliminary documents.

1st report (Europe), by Mr. Van Noorbeeck. (See *Bulletin*, October 1929, p. 2149 or separate issue No. 32.)

2nd report (other countries), by Mostafa Hamdy El Kattan Bey. (See *Bulletin*, September 1929, p. 1941 or separate issue No. 27.)

Special Reporter : Mostafa Hamdy El Kattan Bey. (See *Bulletin*, May, 1930, p. 1540.)

DISCUSSION BY THE SECTION.

Meeting of the 8 May 1930 (morning)

Mr. JACOBS, Vice-President, in the chair.

The President. — Gentlemen, we now come to the discussion of Question XVIII: *Improvements in the permanent way equipment of light railways.*

Mr. Mostafa Hamdy **El Kattan** Bey *Special reporter,* will speak.

Mr. Mostafa Hamdy **El Kattan** Bey read his special report and the résumé of Mr. Van Noorbeeck's report, which appeared in the May 1930 number of the *Bulletin*, pp. 1540 to 1543.

Mr. Marguerat, Viège-Zermatt Ry., Switzerland (in French). — I endorse very willingly the summaries which the Special Reporter has submitted. However, it seems to me that we ought to express a desire regarding the standardisation of rails and sleepers. In point of fact, the Reporters have noted the diversity in the types of rails and sleepers, and you are certainly aware of the fact that, in several Administrations and even in several Associations, investigations have been commenced with a view to the standardisation of permanent way material. There is no doubt that the International Railway Congress Association ought to endorse the efforts which are being made in this direction. The standardisation of permanent way material would certainly constitute a source of economies and would facilitate the replacement of worn or out of date parts. In conclusion, therefore, I would ask the 5th Section to express a desire that in Associations with a view to the standardisation of rails and sleepers should be future the efforts made by the different taken into consideration. In this con-

nection, I would add that the International Tramway Union has appointed a special commission which has already come to conclusive results as regards rails. As regards sleepers, I believe that it will be possible to come to an agreement in the various countries for the adoption of several metal types. Up to just recently, there was a whole series of rails, which made replacements very difficult. In fact, very often, there were no longer any rolling mills capable of providing rails identical with those laid some 40 or 50 years ago, and there are many undertakings which have been in existence for 50 years !

As regards signals, I do not think that much standardisation has been effected in this sphere. However, I would mention that some Administrations have replaced level crossing keepers by luminous or acoustic signalling. This system tends to become more common; in Switzerland, in particular, it has been accepted by the supervising authorities. Its installation is obviously expensive, but the system affords considerable advantages seeing that, for ordinary signals and keepers, the expenses are likewise very great due to the application of the eight hours' day and the costs resulting therefrom.

Optical signalling is also preferable for motorists and other road users. In fact, the latter have become familiar in the towns with this system of signalling, which is applied in an almost identical manner to level crossings. The signal may be manually operated, but when it is placed near a station it may be operated by the station employee or automatically by the train, on arrival and departure. I thought that it would be useful to mention this innovation.

I should also like to draw your attention to the trials which have been made with a view to the mechanical weeding of the track. As everyone knows, weeding is necessitated by the fact that vegetation is constantly growing in the track. This vegetation is all the more abundant, the damper the climate of the countries and, in this case, weeding is expensive. Efforts have been made to reduce these expenses in different ways, and among others a system of knives or shears which cut the weeds has been utilised. This method may be employed with a track having steel sleepers and has given fairly good results. It gives rise to difficulties, however, on narrow gauge tracks.

At the present time, we are making more and more use of the chemical method of weeding using diluted sodium chlorate. This is a very economical method and one which has given very good results. A truck carries a large tank terminating in a perforated pipe, as in the case of a town watering cart. The truck is coupled to a train, locomotive or rail motor car. Preferably, weeding is done immediately after a fall of rain so that the chlorate penetrates the ground as deeply as possible. We have obtained very satisfactory results with this system and practically all the Swiss railways are using it. Besides, it is excessively cheap. It requires very little labour which, being very expensive, must be dispensed with by every possible means.

I would also like to add a few words on the subject of the metal sleeper. In the summaries of his report, Mr. Van Noorbeeck asserts that « it is not, however, extensively used ». This does not apply to Switzerland where almost all the Administrations employ metal sleepers only. By way of example, I would point out that one line has already had them for 40 years and has benefited

considerably from them. We are at present engaged in extending this line and we have not hesitated to use metal sleepers which are the only ones used in Switzerland on secondary railways.

Finally, as regards electric welding, I would point out that electrically welded crossings are made cheaper than cast crossings and it is possible to reface them by electric welding also, which constitutes a considerable saving. By means of electric welding, the rails may be refaced very easily and afterwards undercut *in situ* likewise by an electric process.

Mr. Van Noorbeeck, *Reporter* (in French). — In the course of the interesting account which he has just given us, Mr. Marguerat raised the question of signalling. This is a very complex question and one which is even very dangerous to deal with at a meeting because it may involve us in very lengthy economic considerations. This question, briefly, is subdivided into two parts : safety of the trains on the line; then, safety of the road users.

But according to the programme of questions proposed for discussion at the next Session, which was distributed at the beginning of the meeting, the question of signalling appears on the programme of the 5th Section under the following form : « Measures and equipment for protecting light railway trains and road users at crossings and other dangerous points on the roads. » I therefore consider that occasion to be the moment for discussing this question thoroughly, as it is so important that I think it would be better not to enter into it at present.

As regards the question of metal sleepers, I believe that I pointed out in my report that these sleepers are used in Switzerland, but that they are not used much as yet in the other European countries.

As to the question of maintenance, we cannot deliberately condemn all the systems employed by the great railways, all the more so in view of the fact that they have to be adapted to different and varied situations. In Belgium, for instance, where we are using chiefly clinker ballast, the question does not present itself in the same way as in Switzerland. Moreover, weeding by the process mentioned by Mr. Marguerat has its disadvantages.

Mr. Marguerat (in French). — In reply to Mr. Van Noorbeeck, I would like to say that the only disadvantage of the method of weeding that I mentioned, a disadvantage, moreover, which is inherent to all operations of this character, is the danger of burns for the employees. For this reason, we have tanks which are so designed that the employees have no need to touch them. The product is obviously very corrosive and rather dangerous, but we have never experienced any accident or difficulty. The effect lasts for one year. Even during the following year, sections done the preceding year are found to be perfectly clean. Chemical weeding is much more efficient than the mechanical method and very much cheaper.

The President (in French). — What percentage of sodium chlorate do you use ?

Mr. Marguerat (in French). — The proportion of sodium chlorate is approximately 1 %. Moreover, it is a by-product which we procure from the industry very cheaply.

Mr. Mostafa Hamdy El Kattan Bey (in

French). — I would point out that in Egypt, a country having a slightly damp climate, metal sleepers have not given good results. After seven or eight years, they deteriorate below the rails owing to the moisture and on several occasions we have had to take up the rails in order to examine them. It would appear certain, therefore, that in damp countries, metal sleepers are not used with the same success as in dry countries. Our experience appears to be conclusive on this point.

Mr. Van Leeuw, Ministry of Colonies, Belgium (in French). — What the Special Reporter has just stated regarding metal sleepers is contradicted absolutely by our experience in the Belgian Congo. There, where the country is particularly damp, we have had to abandon radically timber sleepers. The latter behave well for a year or a year and a half at the most, but we have had to replace them everywhere by metal sleepers.

Mr. Marguerat (in French). — In my opinion, it is chiefly a matter of the sub-soil, and not the dampness of the climate. In some tunnels we have to use timber sleepers, and in others, metal sleepers. It is a question of the corrosion by the moisture of the soil.

I should again like the Section to express its desire that in future the efforts made in standardising rails and sleepers should be considered.

The President (in French). — Are there any objections to be made regarding the desire expressed by Mr. Marguerat on the matter of the standardisation of permanent way material ?

— No one asked to speak.

— The Section then adopted unanimously the summaries of the special report and expressed the *desire that the efforts made by the Standardisation Associations with a view to the standardising of rails and sleepers should be taken into consideration.*

The President (in French). — The summaries of the special report having been adopted unanimously, as well as the desire expressed by Mr. Marguerat, it remains for us to thank the eminent Special Reporter for the trouble he has taken and for the interesting report he has kindly presented to us. (*Applause.*)

— The meeting then rose.

DISCUSSION AT THE GENERAL MEETING.

Meeting held on the 10 May 1930 (morning).

President : Mr. José GAYTAN de AYALA.
General Secretaries : Messrs. P. GHILAIN and A. KRAHE.
Assistant General Secretaries : Sir Henry FOWLER, K. B. E., Messrs. P. WOLF and J. M. GARCIA-LOMAS.

Mr. Ghilain, *General Secretary*. — Gentlemen, we will now pass on to the examination of the summaries adopted by the 5th Section with regard to question XVIII.

The text of these summaries is the same as that of the special report, which you have all been able to read.

Are there any remarks in connection with these summaries ?

— No remarks were made.

The President. — The final summaries are consequently as follows :

SUMMARIES.

« Axle loads of the stock are increasing more and more, necessitating well made, dry, and well drained earthworks, and a much stronger and more solid permanent way.

« Any gauge of track can be suitable according to local circumstances.

« Equally, the choice of traction is a matter of convenience.

« The Vignole rail which is almost exclusively used in the lines laid beside high roads or on special earthworks, has the following average characteristics :

« Gauge of track 1.435 m. (4 ft. 8 1/2 inches) : height 140 mm. (5 1/2 inches); width 130 mm. 5 1/8 inches); head 60 mm. (2 3/8 inches), of an average linear weight of 38 kgr. (76.6 lb. per yard). Metre gauge : height 113 mm. (4 7/16 inches); width 90 mm. (3 1/2 inches); head 45 mm. (1 3/4 inches), of an average linear weight of 23 kgr. (46.4 lb. per yard) for the lines worked by steam, and of 125-mm. (5 inches) height, 105-mm. (4 1/8 inches) width, 57-mm. (2 1/4 inches) head, of an average linear weight of 32 kgr. (64.5 lb. per yard) for those worked electrically.

« The length of the rails varies generally between 9 and 18 m. (29 ft. 6 3/8 in. and 59 ft. 5/8 in.) with a tendency towards the latter figure.

« There is a marked preference for leaving the top of the sleepers free from ballast in view of the easier inspection and maintenance of the rail fastenings.

« The choice of the kind of ballast is chiefly guided by economic reasons, although it is recognized that broken stone constitutes the best ballast.

« Corrugated wear of rails only shows itself to a small extent on light railways. The remedy for this trouble can be found in the use of a good and homogeneous steel with a high tensile strength, a high elastic limit and the highest possible elongation. These different characteristics must be in suitable proportions to each other.

« The laying of the track is done with opposite joints on the straight, staggered joints being used only when laying in curves of a radius generally smaller than 100 m. (5 chains).

« Creep is hardly apparent in light railways. It is overcome either by the fixing of angle fishplates to the slee-

« pers, or by stirrups which are fixed « to the rails and the sleepers, or simply « by stirrups against the heads of the « coachscrews.

« Frequently, the rails are laid at an « inclination on the sleepers. This cant « is obtained either by adzing the slee- « pers or by the shape of the sole plate « or the chair. The first mentioned « system is, however, the more generally « used.

« The fishplates of the rails are be- « coming simpler and generalized by the « angle fishplate with four or six bolts; « the loosening of these is chiefly pre- « vented by spring washers, Grover type, « or by tension plates.

« Grooved or twin rails are used on the « inner line of curves of a small radius. « In this case the use, in the outer line, « of rails made of high tensile steel or « special steels (manganese and chrome- « nickel) is recommended.

« Barberot keys can be used with « economy on the outer rails of small « curves.

« The use of sleepers is general. Sleep- « ers of oak, or pine impregnated with « creosote, are the most used.

« The rails are fastened to the wooden « sleepers by means of coachscrews ei- « ther direct or in conjonction with steel « sole plates, without marked preference « for either system.

« When metal sleepers or ferro-con- « crete sleepers are used, the fastening « of the rail is usually by means of « clips and bolts.

« The metal sleeper has advantages as « regards duration and the security of « the fastenings; it is not however ex- « tensively used.

« Concrete sleepers are being increas- « ingly used although they are costly « and rather difficult to handle. The « type consisting of two supports with « large bearing surface joined by a small « metal tie bar or by a ferro-concrete bar « is generally preferred. It gives very « encouraging results.

« The welding of rails is not yet gene- « ral practice.

« Experiments made on a large-scale « and of long duration show, however, « the considerable advantages which can « be obtained therefrom and encourage « the development of its use.

« Thermit welding has up to now only « been employed for new lines, arc weld- « ing for old rails, repairs to points and « crossings and building up of rail ends.

« The process generally adopted when « electrically welding rails consists in « welding the fishplates to the rails, to « stiffen up the joint by a plate welded « under the foot and to weld the heads « of the rails together.

« Electric welding of the rails end to « end without fishplates is, however, de- « veloping and is would be interesting « to see it continued in view of the « encouraging results obtained during « the experiments.

« The limit, as regards length, of the « parts of the line to be welded on spe- « cial site or beside high roads is a mat- « ter of the temperature fluctuations in « the district. For a temperature fluc- « tuation of 60° C. (108° F.) the welded « length can go up to 60 m. (197 feet) « without inconvenience.

« The use of heat treated cast steel in « the manufacture of crossings is deve- « loping and gives very satisfactory re- « sults.

« The experiments with special man- « ganese or chrome-nickel steel for the « manufacture of parts subjected to « much strain (crossings and cross- « overs) have given entire satisfaction « from the economic point of view as « well as from that of wear. »

[621.53]

QUESTION XIX.

ELECTRIFICATION OF SECONDARY LINES.

Preliminary documents.

1st report (Europe), by Mr. L. SEKUTOWICZ. (See *Bulletin*, February 1930, p. 491 or separate issue No. 60.)

2nd report (other countries), by Messrs. E. RIBERA and J. M. GARCIA-LOMAS. (See *Bulletin*, February 1930, p. 665 or separate issue No. 64.)

Special Reporter : Mr. L. SEKUTOWICZ. (See *Bulletin*, May 1930, p. 1544.)

DISCUSSION BY THE SECTION.

Meeting of the 9 May 1930 (morning).

MR. JACOBS, VICE-PRESIDENT, IN THE CHAIR.

The President (in French).— We now come to Question XIX : Electrification of secondary lines. The *Special Reporter*, **Mr. Sekutowicz**, being unable to attend the Congress, Mr. Jourdain will speak.

Mr. Jourdain, Nord-Est Secondary Railways, France, reads the summaries drawn up by the Special Reporter, as they appear on page 1551 of the *Bulletin* for May 1930.

Mr. Lo Balbo, Piedmont Tramways, Italy (in French). — I think that I am expressing the feelings of all our colleagues in offering our hearty congratulations to Mr. Sekutowicz on his report which was published in the *Bulletin of the Railway Congress* for February 1930. Mr. Sekutowicz, in his report, after examining closely the question of the electrification of European light railways and mentioning the advantages of electric traction, draws attention to the financial side of the problem. He has pointed out that electrification with overhead wires might lead to disastrous results on light railways and tramways with small traffic, seeing that electric traction necessitates a considerable capital expenditure which is only justified where the daily traffic is sufficient. This limiting amount of traffic seldom exists in the case of light railways.

Mr. Sekutowicz has therefore mentioned other methods of traction, including the use of accumulator locomotives.

I would like to draw the special attention of the meeting to the use of accumulator rail cars.

The problem of accumulator traction has for a long time been neglected, due to the undeserved prejudice against it.

I say « undeserved prejudice » because it frequently happens in technical matters that not wishing to lose time in unpromising experiments, manufacturers are prevented from obtaining gradual experience, thus retarding progress.

It is true that the tests made 30 years ago in Belgium, France and Italy gave bad results. It must be admitted, however, that at that time the experience of accumulator construction was not as greatly advanced as it is to day. To quote a case, I may mention that the average life of plates was only 11 000 km. (6 835 miles) for positive plates, and 22 000 km. (13 670 miles) for the negative, whereas today for normal traction accumulators it is possible to obtain a life of more than 100 000 km. (62 100 miles) for positive and 200 000 km. (124 200 miles) for negative plates.

Moreover, in 1900 the system of traction by rail motor cars with multiple control whereby, as you are aware, it is possible to couple two or more rail cars and several trailers, without appreciably increasing the cost of operation, was unknown.

I would add that the main reason why certain tests made in 1900 were so unsuccessful arose from the fact that the mixed system of traction was used, that is to say, in which the electric rail cars ran sometimes taking current from an overhead wire and sometimes from a battery of accumulators. Theoretically, under this system the accumulators were charged while the car was taking current from the overhead wire and discharged while running without. A full charge of the batteries was carried out during the night. However, the inevitable variation in the voltage of the overhead wires gave rise, frequently and inevitably, either to excessive over charge or to under charge of the batteries. Moreover, the battery on the cars was arranged as badly as could be imagined from the point of view of inspection and maintenance, a point of view which was not given sufficient consideration until its importance had been demonstrated in practice.

There were also other secondary adverse factors, for example, insufficient insulation of the batteries, incomplete ventilation, spilt acid damaging the underframe, complaints from passengers with regard to the acid fumes and even heavy gradients which caused excessive discharge from the batteries. Under these conditions failure was inevitable and accumulators were strongly criticised and finally condemned.

However, during the last five years the use of accumulator rail cars has again been taken up and a number of railways, tramways and builders are again interesting themselves in this type of vehicle.

In fact, if one examines the statistics of the use and construction of these rail cars, one finds at the present time that there is a marked tendency in their favour, and that by means of these vehicles a number of branch lines and tramways are able to retain passenger traffic which they would otherwise lose.

In view of the results obtained with the electric accumulator cars now in service, I think that we should consider that the question of cost (including not only the first cost, but depreciation and maintenance) has been solved in a satisfactory manner.

There is no doubt that the ideal accumulator for electric traction is that which incorporates the following four features: maximum capacity, minimum weight, minimum volume, maximum life. Unfortunately, in spite of the researches and numerous tests which have been

carried out, even the most improved type of traction accumulator is far from the ideal. If such an accumulator could be produced, it would lead to a revolution in electric traction, the importance of which it would be difficult to estimate at present.

However, considerable progress has been made. One may even say that the ordinary traction accumulators have allowed this method of traction to be used throughout the entire world.

The usual life of accumulators in service is about 600 to 700 complete cycles of discharge and charge. Cases have occurred of batteries installed on electric vehicles which not only have exceeded this amount, but which have reached and sometimes exceeded 1 000 cycles of discharge and charge and a life from 5 to 6 years. The experience gained in Germany with accumulator traction is of considerable interest. In fact, during the last few years a type has been adopted on the lines of the State Railways consisting of six-wheel rail cars coupled in pairs by means of a hinged coupling. In 1929, these accumulator vehicles ran about 11 million tr.-km. (6 835 000 train-miles), showing in every case, not only technically, but also financially, advantages compared with steam traction.

In Italy, during the last 5 years, accumulator electric traction has been encouraged for the following reasons :

1. the expense for maintenance and renewal of the batteries is no longer an unknown factor, as the manufacturers of accumulators bear these costs in return for a small charge per kilometre run.

2. the accumulator system has the great advantage of providing a preliminary service which can be converted to traction by overhead wires when the traffic has increased sufficiently to require and justify this.

I should add that the Italian Government has realised the importance of developing accumulator rail cars, and a decree of the 2 August 1929, lays down that :

« For the electrification of conceded railways and existing steam tramways, and for the adoption of other means than steam traction on these lines where complete electrification is not necessary, the following may be granted :

a) an extension of the terms of repurchase;

b) an extension of the date of the expiration of the concessions;

c) subsidies for each kilometre of line worked under the new system of traction, limited to a maximum of 10 000 lire (16 000 lires per mile) for a period of 50 years for railways and 35 years for tramways dating from the date of the application of the new method of traction. »

Electric accumulator cars are at the present time in service in Italy on about 300 km. (186 miles) of tramways and local railways with satisfactory results.

The advantages which may be attributed to accumulator electric traction are as follows :

1. extreme flexibility of service;

2. all vehicles are completely independent;

3. no maintenance costs for overhead lines (since these do not exist in this case);

4. simplicity and safety in operation;

5. high average speed;

6. cleanliness and absence of noise;

7. frequent service obtained economically and with the best utilisation of the rolling stock.

On account of the above advantages, this system of traction can be used, either for operating lines with a light traffic, or for those with a frequent service. On lines of light traffic, the rail cars can effectively replace trains, while on main lines they can be usefully employed, for example, for suburban service at certain important centres where there are a number of passengers, but the number to be carried in a particular train is small. These vehicles may also be used as feeders to the through trains for which the rail car may collect or distribute passengers.

I will conclude by saying that it is desirable that light railway and tramway administrations should continue their trials to develop the use of this system of traction on lines where this method of electrification is possible. It is therefore desirable that the question of electrification of light railways should remain included in the agenda for the next Congress, meaning thereby electrification which does not require the provision of fixed conductors, such as accumulator traction.

The President (in French). — We will carefully consider Mr. Lo Balbo's conclusions. In Belgium, we are at present making fresh tests of accumulator vehicles. A company has been formed to operate some vehicles at the Liége Exhibition. These will carry heavy traffic, and it is anticipated that the results will be good. Proposals have been put before the Belgian National Light Railway Company on this subject, and we will, if necessary, reconsider this subject when we have had a report on the trials now in hand.

Mr. Jourdain (in French). — I will reply to various points referred to by Mr. Lo Balbo and will make a few additions to the report of Mr. Sekutowicz who has asked me to take his place during the discussion on this question. It is obvious that he has not specially dealt with this point nor as fully as Mr. Lo Balbo has done, but has only referred to it.

However, in France, a certain number of administrations are dealing with this question and we have also made tests. We have not always experienced the cooperation and help from the makers of accumulators that Mr. Lo Balbo has mentioned in the case of Italy. This is a very important point, and our light railways have for this reason moved rather slowly in this matter. It appears that the chief obstacle lies in the unfavourable prices quoted by the makers of accumulators. I quite agree with Mr. Lo Balbo when he says that there is something in the use of accumulators, and that under certain conditions they can give very good results.

These results can be all the better where the power stations supply the current during the night at a very low cost, or better still, during slack periods of the day. The railway administrations on the one hand and the power stations on the other are only too ready to adopt this course, but the principal effort should be made by the makers of accumulators, as it would be of great advantage in developing their industry.

I would add that the question is interesting the Government in France as in Italy. One of our colleagues, Mr. Jeancard, at the meeting of the « Union des Voies Ferrées », at Marseilles in 1927, gave us some very interesting information on this subject. He had equipped

the Charentes Lines with accumulator rail cars, and the French Government had agreed to meet half the expenditure, as in the case of electrified lines.

The information which Mr. Lo Balbo has given us is therefore very valuable. The conclusions might in fact be based on his remarks.

However, where I differ from Mr. Lo Balbo is as regards his demand that the question of electrification of branch lines shall be again placed on the agenda for the forthcoming Congress. The question of accumulator rail cars can be reconsidered seeing that development is continually proceeding, and I hope that in three years time we shall have some definite results, but as regards the general question of electrification of light railways is it really necessary to place this on the agenda for the forthcoming Congress ? I do not think so. Mr. Sekutowicz moreover recognises that a complete electrification of light railways can only be adopted in a very limited number of cases.

The President (in French). — It is for the meeting to decide what is to be done when considering the list of questions suggested for the next Congress.

Mr. Jourdain (in French). — The question of accumulators could be dealt with in conjunction with economical methods of traction, as for example, one might in the first section deal with Diesel engines, and in another section, with the use of accumulators.

Mr. Marguerat, Viège-Zermatt Railway, Switzerland. — Might I point out that the Permanent Commission has requested the Sections to reduce the number of questions for discussion in view of the decision to hold a Congress every three years. I think that the question we are dealing with is more closely connected with rail cars in general than with electrification. Where government assistance is concerned, we are no doubt right in claiming that it is a matter of electrification, but from a technical point of view it is not a question of electrification but rather of the use of rail cars. The Diesel engine is competing with the accumulator, and this will certainly force manufacturers of accumulators to reduce their prices. Diesel engines are already developed to a point where they give very satisfactory and economical results.

Mr. J. F. de Souza, Ministry of Commerce and Communications, Portugal (in French). — Allow me to say a few words on the matter under discussion, which is of particular interest to us in Portugal. We have recently extended our system considerably, especially as regards light railways. In the North of the country, which is very mountainous, we cannot expect very heavy traffic, and it is necessary to build the lines as cheaply as possible. From an operating point of view, electric traction will no doubt give good results, but we cannot expect a large traffic, at any rate to commence with; therefore the lines will be handicapped by their high capital cost. In my opinion the solution of the problem lies in the use of rail cars. Thus, a few months ago it was decided to electrify a conceded suburban line, then in order to postpone the large capital expenditure required for electrification, the Government decided that the concessionnaires should use Diesel rail cars. I should like to know whether this method should be used generally, as we have to make a choice between the two systems. In Por-

tugal, thanks to waterfalls, it is possible to obtain cheap power, but, on the other hand, a large amount of capital is necessary to electrify the line. Careful consideration must therefore be given as to the method of traction to be adopted. It seems to me that many engineers are troubled by doubt, and I hope that today's discussion will clear the matter up.

Mr. Jourdain (in French). — I might say that the problem mentioned by Mr. de Sousa is also engaging our attention in France. I am particularly acquainted with the lines on which we have considered electrification. In spite of the 50 % assistance from the State, the « département » and company have hesitated at the last moment, finding that even half the capital to be invested by them would be disproportionate to the results obtained in operation with an average of three trains per day. At the present moment we are hoping to improve the operation of the line, and negotiations are in hand to equip it with Diesel-electric rail cars.

The President (in French). — I think that these cases occur in all countries. The question also arises in Belgium.

Mr. Jourdain (in French). — I think in fact that many of us are confronted with this problem. The trouble with the Diesel engine is that it costs too much.

The President (in French).— We have carried out tests in Belgium with a Diesel locomotive. We find that a Diesel rail car costs too much and that it is extremely complicated.

Mr. Mellini, Permanent Commission of the Association, *Reporter*, Question XVII. — The Diesel engine is being developed to meet the various traffic requirements, and it will shortly be built by mass production. In Italy it may be said that the experimental period is closing and will open the way to practical applications. As the weight and bulk will be more and more reduced, there only remains the question of the price, which is still high.

Mr. Jourdain (in French). — One can only obtain really conclusive results after extensive experiments. Messrs. Saurer are making trials with a Diesel engine for their motor buses. One of the companies with which I am connected has ordered a bus from this firm, and the latter have asked to be allowed to supply a petrol engine, as the tests with the Diesel have not yet proceeded sufficiently far.

Mr. Allard, *Principal Secretary* (in French). — Messrs. Saurer have also replied to an enquiry which we have made, that it was necessary to wait until the tests had given conclusive results.

Mr. Mellini (in French). — Vehicles equipped with Diesel engines made by Messrs. Saurer are already in experimental service under the Post Office in Switzerland, and the results of these tests are being followed with the closest attention by that Administration. The most recent information I have received on this subject is quite favourable. One may ask therefore why these engines cannot be adopted to rail cars in view of the great interest which there is in a modern and economical method of rail traction. I feel that the caution exhibited by the companies in experimenting in this direction is probably on account of the unfavourable financial position in which they are at the present time. I do not think that from a technical point of view

there are any great difficulties in applying this method.

Mr. Allard (in French). — There is the difficulty of obtaining suitable staff. I believe that we are only in the experimental stage and one cannot say that Diesel cars are quite reliable in operation.

The President. — It seems to me that we can close the general discussion.

We will now pass on to the examination of the proposed conclusions and discuss them paragraph by paragraph.

Has anyone any remarks to make on paragraph 1, which is worded as follows :

1. From the technical point of view, the railway operators have merely to make their selection, monophase current and high tension continuous current with overhead equipment having demonstrated their suitability whilst the principal firms supply perfectly satisfactory equipment.

Mr. Mellini (in French). — Allow me to make a remark on this paragraph. It states :

« From the technical point of view, the railway operators have merely to make their selection, monophase current and high tension continuous current with overhead equipment having demonstrated their suitability... »

In my opinion this conclusion is rather too general. Actually during the last 4 or 5 years, railway practice in the majority of countries has shown a decided tendency in favour of high-tension continuous current. If we examine statistics of a number of countries and systems which have adopted this method of electrification, we find that there is a clear majority as compared with railways which have adopted other systems of electrification, in fact continuous current at 3 000 volts is today the system which has been largely standardised and used throughout the whole world.

Naturally the countries which adopted single-phase current at the time when the problem of the 3 000-volt continuous had not been perfected still continue to use this system, and the results are, from certain points of view, satisfactory. However, if a country had at the present time to decide the problem without any precedent or other special reasons, I feel sure that in a large majority of cases, if not in every case, the choice would be high-tension continuous current electrification.

For this reason I think it would be well to modify the wording of this paragraph as follows :

« In the present state of our experience and although the use of single-phase current is always capable of giving good results, where no special reasons exist for any particular choice of system, a slight preference should be given to high-tension continuous current. »

Mr. Marguerat (in French). — I much regret that I do not share this opinion. We have for a long time hesitated between high-tension continuous current and single-phase. The source from which power is obtained is an important factor. We have available single-phase current at 15 000 volts used by the Federal Railways, and we can connect up direct with this System.

We have also available three-phase current at 50 periods, and it would also have been easy to use continuous current. However, the results obtained in Switzerland with single-phase current are remarkable. The contact wire can carry high-tension, while the motors use low tension.

This feature is of great importance, especially for the secondary motors. We have had a line in service for nearly a year and have experienced no difficulty. Seeing that this was the first application of single-phase current to be carried out to a rack and adhesion line, we rather hesitated in choosing the type of current. The advantage of single-phase current is that we can use the whole range of speeds, whereas with continuous current we should have been limited. I would emphasize that we have carefully investigated the whole question before adopting single-phase current on a rack and adhesion line. We are entirely satisfied and the results have been perfect and are a credit to the builders of the locomotives. Further, for the Rhætian Railway, which is entirely in a mountainous region, we have adopted this type of current, power being supplied as single-phase current at 11 000 volts.

I cannot therefore agree with Mr. Mellini, in view of the remarkable results which we have obtained with single-phase current.

Mr. Jourdain (in French). — I think that fundamentally we shall agree in stating that the companies which have adopted single-phase current, especially in the more recent installations, are highly satisfied, but I believe that the railways which today employ it are generally those which have at their disposal a supply of single-phase current, as in the case which has just been quoted. I know of a similar case of this kind in France, namely the Camargue Railways. On this System the conditions are exceptional. It has been authorised to take current directly from an alternating current network distributing current at a frequency of 25 periods.

On the other hand, on railways which are not supplied from any particular source, there is a general tendency to use continuous current.

Mr. Bouteau, General Light Railway Company, France (in French).— I think that we should avoid making a definite pronouncement on this question whatever opinions we may have among ourselves as regards single-phase and continuous current, so that we may not embarrass, in their dealings with the conceding powers, those of our colleagues who have decided to use single-phase current. Thus, we have in France the Aisne Railway, an important system comprising 600 km. (373 miles) of line which, at the present time, is electrified with single-phase current. The single-phase current has certain advantages, mainly that it avoids the very high first cost which is necessary with continuous current. One may therefore be obliged under certain conditions to use single-phase current, and it would be regrettable if our recommendations should make it difficult for those of our colleagues who have to do so.

The President (in French). — Do you not think that the reporter has tried to suit everybody? In saying that any choice is difficult, he does not give preference to either of the two systems. The different cases which may be mentioned are special cases. If, however, there is a tendency to prefer the continuous current, that is not to say that single-phase current should not be used under certain circumstances.

Can the first summary therefore be adopted as worded by the Special Reporter?

— Adopted.

We pass therefore to the 2nd summary which is worded as follows :

2. Electrification of the main lines, and that of large areas by utilising natural motive forces and the recent improvements in mercury vapour rectifiers have facilitated the use of electric traction, particularly in the case of high-tension continuous current, which has been made possible by the use of motors with commutating poles.

-- Adopted without modification.

Summary 3 :

3. From the economic standpoint, however, electrification is mostly only possible in the case of *new* lines, which also possess features favourable to the system (cheap current, dear coal, sufficiently heavy passenger traffic, difficult lines, necessity of meeting competition).

Does anyone wish to speak on this paragraph

Mr. Marguerat (in French). — I think that the wording is rather inadequate. We should also mention existing lines. There are special cases to consider, for example, old lines which one wishes to electrify, or those on which old rolling stock is in use which does not meet present-day requirements. In a case of this kind, electrification is justified. I think it would be better to slightly modify the text and to say : « or possessing features favourable to the system. »

Mr. Jourdain (in French). — I think that this would rather alter what the Reporter wishes to say. He recommends general electrification on « *new* lines which possess, etc. ». What Mr. Marguerat proposes would alter this to the following form : « From the economic standpoint, electrification is generally justified only in the case of new lines which possess features favourable to the system. »

Mr. Allard (in French). — The text therefore excludes the old lines. I believe this is the intention of the Reporter.

Mr. Jourdain (in French). — One might say : « lines possessing features favourable to the system. » Since Mr. Marguerat wishes to point out that there are old lines with worn out rolling stock which could be well replaced, we might make an addition.

Mr. Allard (in French). — It would be better to retain the original text and add : « in certain particular cases on old lines. »

Mr. Jourdain (in French). — I propose the following text :

« From the economic standpoint, however, electrification is generally only justifiable in the case of lines possessing features favourable to the system... and above all in the case of new lines. »

Mr. Mellini (in French). — We might say : « in the case of new lines and of existing lines which it is found desirable to modernize. »

Mr. Jourdain (in French). — We must take into account what we have said during the discussion on Question XVII, on the subject of feeder lines.

Mr. Marguerat (in French).— It seems to me that we have slightly altered the meaning of the Special Reporter. It is correctly stated : « from the economic standpoint »; I think that the point we are now dealing with is not an economic question.

Mr. **Mellini** (in French). — It is well an economic question.

Mr. **Marguerat** (in French). — The Special Reporter has wished to point out that in certain cases there is an economic advantage in electrification.

Mr. **Jourdain** (in French). — I think we might say : « From the economic standpoint, however, electrification is generally only justifiable in the case of lines which possess features favourable to the system (cheap current, etc.) and, above all, in the case of new lines. »

The President. — It seems to me that this wording will be satisfactory, as it covers all cases. (*Signs of approval.*)

We will therefore pass to paragraph 4:

4. Nevertheless, especially in new countries, the general interest may lead to the adoption of solutions which are not fully justified from the point of view of the return on invested capital, but necessary for the development of the country. In this case, it may be of interest for the community to cover the expenses of electrification out of the national or provincial budgets, so that the burden of those expenses will then in part fall upon the tax-payers, and not on the users alone. This, moreover, is the case with roads, canals, etc.

— Adopted.

We now come to paragraph 5 :

5. « Complete » electrification of secondary lines, including in this term the electrification of the rolling stock and the construction of the power supply system is only possible, therefore, from the economic point of view, with the proviso mentioned above, namely, in countries or regions where electric power is distributed on a wide scale and may be obtained under exceptionally advantageous conditions, such conditions being promoted by the growth of the population and the corresponding increase in the passenger traffic.

Mr. **Van Noorbeeck**, Belgian National Light Railway Company (in French). — It seems to me that paragraph 5 is a repetition of the preceding paragraph. It also states in the wording : «... under the proviso mentioned above... »

The President. — Perhaps it would be better to delete this paragraph, as the conclusion should be as concise as possible. (*Approved.*)

We will delete paragraph 5 and pass on to 6 :

6. In the case where special systems are employed for certain traffic, especially the passenger traffic, it is possible with the Spanish reporters, to call « incomplete » electrification the electrification alone of the motive material, carried into effect either by producing the necessary electric energy in rail motor vehicles (Diesel-electric or gas-electric motor vehicles) or by accumulating the energy taken from an external source (traction by means of accumulators). This solution is interesting for those railways, both secondary and principal, which serve sparsely populated districts, or which are in competition with other modes of transport. Such is the case when the investment of considerable capital in « complete » electrification is not justified by the density of the passenger traffic or by the saving which might be effected by substituting electric traction for steam traction, as regards passenger traffic, or even goods traffic.

Mr. **Beghin**, Departmental Railways, France (in French). — In paragraph 5 we were dealing with « complete electrification » of branch lines, and the Special Reporter emphasises the word « complete ». He means thereby, not only the

electrification of the rolling stock, but also the provision of conductor lines. He is therefore dealing both with electrification of the rolling stock and the construction of power stations. This paragraph therefore deals with a feature which is not included in the preceding paragraphs. If we delete the 5th paragraph, it will therefore perhaps be necessary to make an addition, say to paragraph 3.

Mr. Allard (in French).— As a matter of fact, the Special Reporter has only drawn attention to the question of cost of current. Would it not be possible to delete both paragraphs 5 and 6? The former will be found to be included in the preceding clauses, and paragraph 6 deals rather with the question of rail cars than with electrification.

Mr. Lo Balbo. — Allow me to ask that paragraph 6 should be retained, but modified. I would say: When electrification is justified neither by the density of the passenger traffic nor by the economies which would result from the substitution of electric traction for steam traction, the use of Diesel-electric rail cars and also traction by electric accumulators may provide very satisfactory solutions.

Mr. Allard (in French). — It seems to me that we are getting rather outside the scope of the question. I think that by electrification we should infer the usual meaning of the term: « electrification of rolling stock, equipment of lines and sub-stations. » I think that the question of Diesel rail cars and accumulator rail cars should not be discussed here.

Mr. Beghin (in French). — I also think that what our Italian colleague proposes would be better included in the discussion on question XX dealing with rail cars.

At the time when I prepared my report, the question of accumulator rail cars had not advanced to its present state. I also intended to prepare an addendum, which would take into account, not only accumulator rail cars, but also the charcoal rail cars which have been put in service in France since my report was written; therefore, if our colleague does not object we could resume this question during the discussion of question XX and add a special paragraph to the conclusions.

Mr. Bouteau (in French). — I think it would be better to let part of paragraph 6 remain. Since, in France, the Government has agreed that electrification by rail cars is bona fide electrification and eligible to State assistance, we might let the wording « incomplete electrification » stand.

The President. — If we retain paragraph 6, proposed by Mr. Bouteau, paragraph 5 should also remain.

Mr. Bouteau (in French). — Paragraph 3 might be amended to read « *complete* electrification ». We could then delete paragraph 5 under these conditions and let paragraph 6 remain.

Mr. Mellini (in French). — Under these circumstances it will be necessary to ensure that paragraph 2 which mentions electrification should agree.

Mr. Bouteau (in French). — As regards paragraph 2, there can be no doubt about this. We cannot here be dealing only with rolling stock, but rather with *complete* electrification, since it is dealing with the motive power.

Mr. Marguerat (in French). — In using the term: « complete electrifica-

tion » it is necessary to define it; thus, Mr. Sekutowicz in paragraph 5 says : « complete electrification..., including by this term, etc. » I would ask if it is not simpler not to define what we call complete or incomplete electrification. In certain countries State subsidies are granted, and it is preferable, in order to avoid any difficulties, not to define the term used. In paragraph 6 we should delete the words « with the Spanish reporters », and merely say : « electrification of the motive vehicles alone ».

Mr. Bouteau. — I support Mr. Marguerat's proposal.

Mr. Marguerat (in French). — At the end of paragraph 6, it is also necessary to delete the words « complete electrification ».

Mr. Lo Balbo. — I think it would be well to draw attention to the economic side of the question and I propose to say : « When electrification is justified neither by the density of the traffic nor by the economies which might be effected by the substitution of electric traction for steam traction, satisfactory solutions may be obtained by the electrification of the motive vehicles alone. »

Mr. Marguerat (in French). — It seems that the wording : « electrification is justified neither... nor... » is rather undesirable. I think it would be better to be more exact and say : « electrifica- of the rolling stock alone. »

Mr. Beghin (in French). — I think that some of our colleagues, particularly our French colleagues, fear that electrification of rolling stock, with which we are now dealing, may not be included as electrification, and that this is contrary to the regulations which accept electrification of the rolling stock as electrification pure and simple. I think that under these conditions it would be better not to say : « When electrification is justified neither... nor... » and replace this wording by the following : « When the installation of contact lines is not justified, the problem may be solved either by the electrification of rolling stock only, or by the use of rail motor vehicles. »

Mr. Allard (in French). — We could say : « When the installation of contact lines is justified neither by the density of the traffic nor by the savings which might be effected by the substitution of electric traction for steam traction, the problem may be solved either by the electrification of rolling stock only, or by the use of rail motor vehicles. »

Mr. Bouton. — I should avoid the words : « is not justified » and say : « One may consider under certain special cases electrification of the rolling stock only... » That would be very simple.

Mr. Allard.— The following text seems to me likely to meet everybody's views : « When it is desired to avoid the installation of contact lines, the problem may be solved either by the electrification of rolling stock only, or by the use of rail motor vehicles », the electrification of the motor vehicles signifying the use of accumulators.

The President. — Does everybody agree with this wording ?

— Adopted.

The President. — We have therefore finished the discussion on Question XIX.

We very much regret the absence of Mr. Sekutowicz. We should have been very pleased to have been able to congratulate him and thank him deeply for the very able report which he has presented. (*Applause.*)

— The meeting terminated at mid-day.

DISCUSSION AT THE GENERAL MEETING.

Meeting on the 10 May 1930 (morning).

PRESIDENT : MR. JOSÉ GAYTAN DE AYALA.
GENERAL SECRETARIES : MESSRS. P. GHILAIN AND A. KRAHE.
ASSISTANT GENERAL SECRETARIES : SIR HENRY FOWLER, K. B. E., MESSRS. P. WOLF AND J. M. GARCIA-LOMAS.

Mr. Ghilain, *General Secretary.* — Next we come to Question XIX, the summaries of which have been published in the *Daily Journal of the Session.*

Are there any remarks with regard to the wording ?

— Nobody wished to speek.

The President. — The final summaries are consequently as follows :

SUMMARIES.

« 1. From the technical point of view, « the railway operators have merely to « make their selection, single phase cur- « rent and high tension continuous cur- « rent with overhead equipment having « demonstrated their suitability whilst « the principal firms supply perfectly « satisfactory equipment.

« 2. Electrification of the main lines, « and that of large areas by utilising na- « tural motive forces and the recent im- « provements in mercury vapour rectifi- « ers have facilitated the use of electric « traction, particularly in the case of « high tension continuous current, which « has been made possible by the use of « motors with commutating poles.

« 3. From the economic standpoint, « however, electrification is generally « only justifiable in the case of lines « which possess features favourable to « the system (cheap current, dear coal, « sufficiently heavy passenger traffic, « difficult conditions, necessity of mee- « ting competition), and, above all, in « the case of new lines.

« 4. Nevertheless, especially in new « countries, the general interest may lead « to the adoption of solutions which are « not fully justified from the point of « view of the return on the invested ca- « pital, but necessary for the develop- « ment of the country. In such cases it « may be in the interests of the commu- « nity to cover the expenses of electrifi- « cation out of the national or provin- « cial budgets, so that the burden of « those expenses will then in part fall « upon the tax-payers, and not on the « users alone. This moreover, is the « case with roads, canals, etc.

« 5. When it is desired to avoid the « installation of contact lines, the pro- « blem may be solved either by the elec- « trification of rolling stock only, or by « the use of rail motor vehicles. »

[621.132 8]

QUESTION XX.

RAIL MOTOR VEHICLES.

Preliminary documents.

1st report (France), by Mr. Paul Beghin. (See *Bulletin*, October 1929, p. 2203 or separate issue No. 33.)

2nd report (all countries, except Europe), by Messrs. C. E. Brooks and R. G. Gage. (See *Bulletin*, October 1929, p. 2229 or separate issue No. 34.)

3rd report (Europe, except France), by Mr. Z. Zavadjil. (See *Bulletin*, February 1930, p. 443 or separate issue No. 59.)

Special Reporter : Mr. P. Beghin. (See *Bulletin*, May 1930, p. 1552.)

DISCUSSION BY THE SECTION.

Meeting held on the 12 May 1930 (morning).

3rd and 5th Sections meeting jointly.

The discussion of Question XX was combined with that of question XII, chapter A, entitled :

« **Economical traction methods for use in particular cases, as for example :**

A) Organisation of train services on the minor lines of the large systems, carrying little traffic, and of little used trains on the more important lines of these systems »

which was published in the March 1931 number of the Bulletin, pp. 352 to 371.

We will consequently limit ourselves to giving hereafter the final text of the summaries adopted for question XX, as ratified by the General Meeting held on the 14 May 1930.

SUMMARIES.

« From the three reports presented it « appears that :

« 1. In France, up to the present, it « has been the general practice to ma- « nufacture light rail motor vehicles « fitted with petrol engines, the Diesel « engine having so far been little used « owing to its high weight and cost.

« 2. In the other countries of Europe « two types of internal combustion mo- « tor vehicles are in use :

« A light type with a power of less « than 100 H. P. usually fitted with a « petrol engine and with mechanical « transmission;

« A heavy type of 180 to 250 H. P.

« with Diesel engine and with electric
« transmission.

« In Europe use is also made of accu-
« mulator motor vehicles and internal
« combustion vehicles using producer
« gas.

« 3. Throughout the rest of the world
« all these types are found, with a
« strongly marked tendency in the Uni-
« ted States and Canada to very high
« power, using Diesel engines with elec-
« tric transmission.

« The reports unanimously agree in
« stating that when the power exceeds
« 150 H. P., electric transmission is
« esential, and all find an appreciable
« saving in the use of rail motor coaches.

« To summarize, it may be stated that:

« Wherever traffic permits of the
« substitution of a motor vehicle for
« a steam train, experience shows that
« the substitution is financially an ad-
« vantage, and this advantage will be-
« come more appreciable when the tests
« at present in progress with new fuels
« (heavy oil, charcoal, etc.), and even
« with other sources of energy, such as
« electric accumulators, have confirmed
« the results achieved to date.

« Further, the Congress expresses the
« hope that manufacturers will produce
« standardized types, thereby reducing
« the first cost, which up to the present
« has been so high as to prevent the
« general adoption of those rail motor
« vehicles the use of which is really eco-
« nomical. »

[621.338]

The advantages and disadvantages of articulated cars

in railway operation, more particularly for services in densely populated suburban districts,

by AD. M. HUG,

Eng. ETHZ, Member S. I. A., F. I. D. C., I., Mech. F., A. E. R. E. A.,
Consulting Engineer, Thalwil-Zurich, Switzerland.

Figs. 1 to 10, pp. 705 to 719.

Summary. — The question as to the desirability of using articulated cars in railway operation is a very much debated point and one on which there are diverse views. Of undoubted interest as regards suburban services, it appears to be looked upon favourably in the United States of America, in England and in some overseas countries. In Germany, articulated types of trains are used on local railways and tramways. The author describes several interesting applications and endeavours to analyse the advantages and disadvantages arising out of the use of articulated cars, both as regards actual operation and from the point of view of maintenance and labour. The subject is considered in connection with the following questions :

1. Reduction of tare and above all a reduction in the dead weight per unit of useful weight carried.

2. The application of radial axles in those cases in which such axles may be employed with advantage instead of four-wheeled bogies.

3. The value of the coefficient of adhesion and its variations (this last point obviously only concerning rail motor cars).

The author is of the opinion that the three questions are too closely related to permit them to be dealt with separately in a paper on articulated cars.

* * *

We shall begin by noting that from 1928 to 1929, the number of articulated trains in service in the various countries increased by about 10 %. Actually, in thirteen of the important railway concerns (there are obviously more) that up to the present time have adopted this type of vehicle, the number of trains has increased from 582 to 638, and the total number of cars composing these trains has increased from 1 990 to 2 155, from which it follows that the average articulated train comprises from three to four cars. One some railways, trains of five, eight and even ten cars have been put into service or have been suggested, but it appears that the general tendency is towards a train of two or three cars (exceptionally four), which would ap-

pear to embody the largest number which can be dealt with by this system.

All these applications relate to suburban services and it should be stated at once that for main line service (by which is meant transport over long distances, greater than about 30 to 50 km. (18.6 to 31 miles), where there can be no question of suburban services), the use of articulated cars loses much of its interest. On the one hand, in view of the different destinations of the cars, and the few passengers they sometimes carry, depending upon the points served and the season of the year and time of day, it is necessary to be able to separate the units. Moreover, the number of passengers carried by a modern coach is generally large already. On the other hand, the maintenance of articulated cars is of a somewhat specialised character, rendering undesirable any decentralisation of the vehicles or their use too far from headquarters. Thus, without going any further into this side of the subject, we shall proceed to discuss articulated trains for suburban services.

Two classes of trains are to be dealt with, namely :

a) Trains made up of rail motor cars and trailers (these trains are sometimes equipped with driving axles only), composed of two or three cars connected together, the articulation being supported either on a bogie or, if the case arises, on a radial axle. These trains are almost always used with electric traction. They may also be provided, however, for petrol-engine or Diesel-engine rail motor cars, or for Diesel-electric traction, or finally as steam motor cars, an exceptional case of which one example will be given (see figures 1, 2, 3 and 4).

b) Trains formed of cars alone (trailers), drawn by a locomotive (the mode of traction being immaterial) and which are generally composed of 5 to 6 cars and in some cases even 8 to 10. (Figure 1 shows a general case which may be applied to both *a*) and *b*), the number of cars in the train being, moreover, immaterial).

Both of these two systems are applicable to suburban service, the first in all cases, but principally for electric traction; the second for relatively heavy trains on extremely intense suburban services, for example, those of London, Paris and Berlin. The fact must be emphasised that with the first system, articulated motor car trains of 2 to 3 cars are advantageous for *any suburban service*, provided it is effected by electric traction. Actually, it may be employed either for a service having a succession of light trains at very short intervals (occasionally 2 to 3 minutes only) or for less intense services, with 15 to 30 minutes' intervals. In these two cases, also, there is nothing to prevent heavier intermediate trains of the ordinary type being put on during the rush hours.

We shall first of all deal with these short and light rail motor car trains for suburban service, considering the almost universal case of electric traction.

Without wishing at this point to give exact statistics concerning all the applications of articulated cars, statistics which, moreover, are not available [the reader is referred to those published by the Committee on Heavy Electric Traction of the Engineering Association A. E. R. A. (1)], it may be said that the type most employed up to the present consists of a double articulated car com-

(1) See Publication No. 301, Subject 4, « Articulated Train Operation » of the American Electric Railway Association (A. E. R. A.) (Convention et Atlantic City, 1929).

prising in all three bogies, the two end bogies being driven, each being equipped with two motors, the central bogie, which supports the articulated joint, being merely a carrying bogie. The first application to be made on an extensive scale in this direction was due to the initiative of the Milwaukee Electric Railway and Light Co., which put into service as early as 1919, 194 trains of this type intended more particularly for town service. New trains in course of construction are intended for inter-urban service. It is curious to note that almost all the existing articulated motor car trains are to found in America, while in Europe it is chiefly trailer cars with which we are concerned. This is probably due to the fact that electrification of the suburban services is less common in Europe and is, to some extent, more recent and less developed than in America.

The following may be given as the advantages of a rail motor car triple articulated train (that is having three cars) as compared with a train made up of one or two rail motor cars, to which are coupled 2 or 1 trailers respectively to make up the three vehicles.

a) Considerable saving in weight in the tare of the train, in view of the fact that, apart from the end bogies of the train, the four intermediate bogies may be replaced by two bogies only, or if the axle loads permit, even by two radial axles instead of four-wheel bogies, this particularly being the case where sufficient power is obtained by equipping the train with four motors (two on each of the end bogies). The slight increase in weight which may be required for the rather long portion between the pivots of the bogies or the radial axles is largely compensated for by the elimination

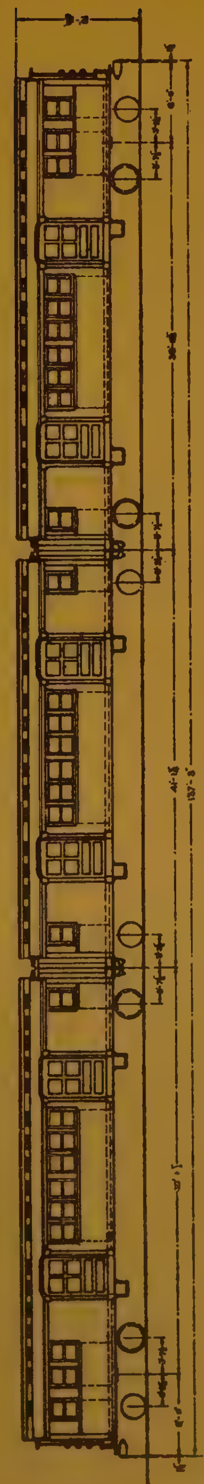

Fig. 1. — Standard type of triple articulated car (electric rail motor cars of the New York Rapid Transit Corporation).

of the draw and buffer gear between the cars of the ordinary train.

b) An indirect consequence resulting from *a* arises from the fact that, in particular, the total number of axles being reduced from 12 to 8 only or even 6, the non-suspended weight of the train is appreciably diminished (to about 2/3 or even 1/2) the effect of which is to diminish the shocks transmitted to the vehicles during running, and consequently to render them easier to construct and give them a longer life. Moreover, this circumstance facilitates the use of light metals instead of steel, a factor which is capable of contributing in a large measure to reducing the tare of the cars and consequently to increasing the proportion of useful weight carried per unit weight of tare, which may be called dead weight, since it has to be carried always, irrespective of the load and the number of passengers on the train.

It is the writer's opinion that the advantages enumerated under *a*) and *b*) exceed all the others which are mentioned in what follows and in themselves fully justify the use of the articulated train.

c) The total length of an articulated train is shorter for the same carrying capacity, which may always be regarded as an advantage from several points of view.

d) The articulated train permits easier passage from one car to another, and by virtue of this fact, enables a smaller number of doors to be provided, whence a saving in weight and space. On the other hand, the space occupied by the platforms in ordinary cars can be better utilised with articulated cars. These three factors render possible the provision of a larger number of places for the passengers (both seats and standing room) than in ordinary cars of the same dimensions.

e) The articulated train being equipped, in principle, with a driver's cab at either end, reversibility in service is perfect. In trains made up of motor cars and separate trailers, on the contrary, it is always necessary to see that the trailers are placed with the driver's cab at the front in the running direction. Actually, for reasons of economy and simplicity, the trailers are equipped with one driver's cab only.

f) Elimination, in many instances, of multiple-unit control. Actually, it will only be necessary to provide multiple-unit control when the operating conditions require two or more articulated trains to be coupled together. However, if the running of light trains succeeding one another at short intervals is admitted in principle, it may not be necessary to make provision for coupling several trains, especially if the traffic in the heavy rush hours necessitates at all events the interposition of heavy trains between the light trains. The writer's opinion has always been and still is that multiple-unit control is a disadvantage, unavoidable in many suburban services operated with rail motor cars, but still a disadvantage because it complicates considerably the equipment of the motor cars and trailers, and in a large measure increase the maintenance costs, both in operation and in the workshops.

g) A train of two or three articulated cars makes it possible to distribute the electrical equipment over the two or three cars of the train. By virtue of this fact, the load due to the electrical equipment can be distributed over all the axles, which is an advantage from the point of view of good running and in certain cases also facilitates adhesion.

In addition, the apparatus is much more accessible, and therefore, as a general rule, maintenance is done better and cheaper.

Reference has already been made to the Milwaukee Electric Railway and Light Co., possessing the most extensive application of articulated trains in the form of double rail motor cars, designed as light trains succeeding one another at short intervals. It may be of interest to mention three other American concerns, namely :

1. The subway system of the Brooklyn-Manhattan Transit Corporation [1] which has put into service, since 1923, triple articulated cars, called « triplex cars », 121 of which were in operation by the beginning of 1929. Figure 2 shows one of these triplex cars. The two end bogies only are driving bogies, each being provided with two motors suspended tramway fashion, each motor being of 200 H. P. per hour for 600 volts D. C. at the terminals, while the two intermediate bogies are merely carrying bogies, situated directly underneath the articulated joint connecting the cars together and supporting the ends of two adjacent cars.

2. The New York Rapid Transit Corporation, which likewise has in service 121 trains of triple rail motor cars comprising a total of four bogies, but unlike the preceding example, each bogie is only provided with one 200-H. P. motor. Figure 1 shows one of these triple motor cars in elevation and it will be seen that only the axles 2, 3, 6 and 7 with the gear wheel shown in dotted line are the driving axles. If our information is correct, these axles have a wheel diameter slightly larger than that of the carrying axles. It will be seen also that, undoubtedly with a view to simplifying the equipment and assembly of the cables, only the axles supporting the outer bodies of the articulated train are driving axles. These trains are intended exclusively for metropolitan service on a special elevated railway section.

3. Finally, the Cleveland Railway Company, which has in service 28 double articulated units with 3 four-wheel bogies, each of the three bogies being equipped with two 50-H. P. motors [1], the power of a double motor car being thus 300 horse. Figure 3 shows one of these units intended more particularly for town service. It should be noted here that much less difference is made in America than in Europe between town service properly so called (which is somewhat similar to that of the tramways in Europe) and suburban service or even inter-urban service for centres situated close together.

In connection with these important American applications, it may be mentioned at this point that the New York Rapid Transit Corporation is very satisfied with its articulated trains and has no other type of rolling stock under consideration for the future. On the other hand, the Milwaukee Electric Railway & Light Company, previously mentioned on two occasions, considers that articulated cars afford the best means of profitably modernising old stock which otherwise would have to be withdrawn from operation. The writer considers

(1) See the number of this *Bulletin* for July 1929, pages 927-929 (Report No. 2, America, on Question VII for the Madrid Congress, by J. V. B. Duer, Pennsylvania Railroad).

(1) The *driving* bogie supporting the articulation is a patent of the J. G. Brill Company, Philadelphia, Pa., U. S. A.

that this last point is of great interest.

We have seen that in the constructions shown in figures 1 and 2 (as well as those forming the subject of figures 5 and 6 to follow), the ends of the bodies each rest on their own centre. These centres (except in the case shown in figure 5) are located at the sides of one and the same bogie supporting the articulation. There also exist, both in Europe and America, constructions in which the articulation itself rests on a central pivot of the bogie common to the two cars. Examples of this are given in figure 3 and also in figure 4 which shows the articulation of the high-speed rail motor cars of the Washington, Baltimore & Annapolis Electric Railroad Company.

We now come to some European applications. It was mentioned at the outset that it is necessary to distinguish

Fig. 2. — Triple articulated (multiple-unit) rail motor car for the subway service, 1925 class, of the Brooklyn-Manhattan Transit Corporation.

between short and light rail motor car trains and trains drawn by locomotives and composed of a large number of cars. The London & North Eastern Railway (LNER) at the present time has in operation about 230 articulated trains, which have been put successively in service since 1927. The formation of the trains varies considerably : about sixty of them are double cars comprising in all three bogies. Other trains are composed of 3, 4, 5, 6, 7 or 8 cars articulated together. Finally, 33 trains are composed of 10 cars comprising in all 12 bogies. On the LNER these trains are solely drawn trains coupled to steam locomotives. All the trains are intended for service on the main lines of the railway. Some of the triple units are equipped as dining cars or sleeping cars.

It is curious to note that about half of all these articulated trains of the LNER have also been formed of old stock which has been modernised. We

have just mentioned that this is the case for the very large majority of the trains of the Milwaukee Company.

Another interesting system of articulated cars is that which has been employed for some time by the secondary railways in Saxony, particularly in the suburbs of Dresden and Leipzig. In existing stock, this system is represented by a triple articulated rail motor car composed of two cars, each having two fixed axles provided with motors, the rigid wheel base of these cars being 3.50 m. (11 ft. 6 in.). A car body but without axles on wheels is interposed and suspended between these two cars, to which it is connected by articulation. This section is supported and pivoted at either end on the ends of the bodies of the adjacent cars. We have thus a triple articulated car having 4 driving axles in all. This articulated train, an example of which is shown in figure 5, on a large radius curve, is very advantageous from the point of view of weight and the satisfactory utilisation of the available space for the passengers, and it was thought of interest to mention it here. Similar cars are in service on some of the Berlin tramway lines (Berliner Verkehrs A.-G.).

In British India, the Great Indian Peninsula Railway and the Bengal Nagpur Railway have some short trains of 2 or 3 articulated cars, which are drawn by steam locomotives and are for service on the main lines. Finally, the Egyptian State Railways (ESR) and the Ceylon Government Railways utilise, for the different gauges of these railways, double articulated rail motor cars for steam traction, the central bogie comprising two coupled axles driven directly by a steam engine of the vertical type. The two ends of the double articulated car are provided with a driver's cab for

Photograph : The J. G. Brill Co.

Fig. 3. — Double articulated rail motor car (unit) of the Cleveland Railway Company.

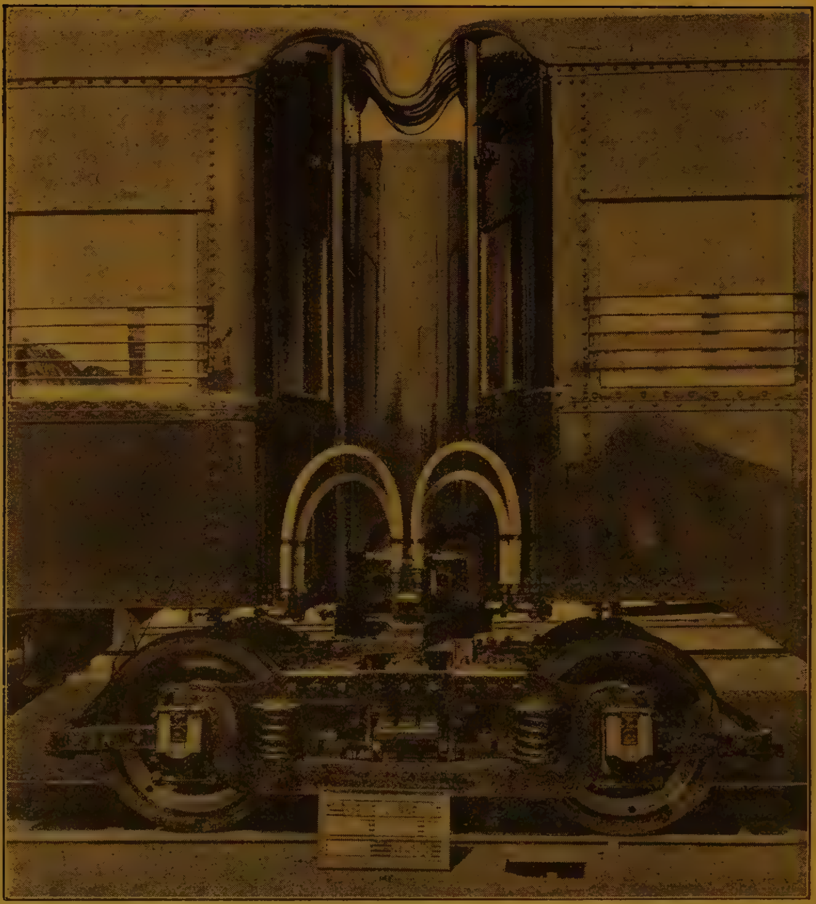

Fig. 4. — Articulation of the high-speed rail motor cars of the Washington, Baltimore & Annapolis Electric Railroad Company.

the control of the engine (see figure 6) (1).

In addition, the writer also knows, without being able to mention them, seeing that as yet it is only a matter of designs, that several large continental undertakings are considering the construction of articulated trains of the most modern type, extra light trains, making it possible to carry about 10 % more passengers, both seated and standing for only two thirds of the tare of the corresponding old types. Such a train of 5 cars would have an overall length of

(1) See in the number of this *Bulletin* for December 1929, pages 673-674 ans 676-678 (Report n° 2, Question XIX : *Electrification of secondary lines*, for the Madrid Congress, by Messrs. J. E. RIBERA and J. M. GARCIA-LOMAS).

96 m. (315 feet) and would be capable of carrying a total of 1 550 passengers for a tare of a little less than 250 t. (246 Engl. tons) which is a tare of about 160 kgr. (353 lb.) per passenger, when the train is fully loaded.

There should be mentioned at this point one application of double cars which are, in a way, semi-articulated. These are two suburban trains put into service about 1927 by the Swiss Federal Railways for the suburban services of Zurich and Basle. These trains are formed of one motor vehicle having two driving bogies as leading car (or end car, according to the direction the train is running), then three double cars having 2 sets of 2 axles (no bogies), permanently coupled in pairs, without draw and buffer gear. The train is completed by a driver's car having two bogies (like the motor vehicle, but without motors) connected to the motor vehicle for remote multiple-unit control. Properly speaking, therefore, these are not articulated cars, since they have not a bogie common to two cars, but the analogy is nevertheless close as the train is also in accordance with the principle of concentrating the number of places in a shorter length of train, while facilitating the passage from one half car to the adjacent car. Figure 7 shows one of these double cars type C-C, No. 5704, utilised for these trains.

From the number on the bodies and the carrying capacity and the tare shown, it will be seen that although we have here two distinct cars which may be separated, the railway administration only regards them as a single unit weighing 29.5 t. (29 Engl. tons) and having 111 places. The entire train weighs fully loaded about 216 t. (213 1/2 Engl. tons) with about 450 places, assuming 20 standing places per car or double car. The average weight (tare) of these trains is therefore about 350 kgr. (772 lb.) per person, and the overall length of the train is 114 m. (374 feet). These trains are painted white and blue so as to distinguish the local traffic from that of the main lines.

The Administration of the State Railway Company in Germany (Deutsche Reichsbahngesellschaft-DRG), possess absolutely identical double cars which the writer has seen running, particularly in the suburban services of Stuttgart [1].

Similar double rail motor cars (having a total of 4 bogies, but with a short semi-permanent coupling between the two cars) were put into service about 1924 with the chief object of reducing weight (this arrangement having been combined with others) on the third-rail electric lines of the East Boston Tunnel (Boston Elevated) [2].

Finally, the last application which deserves mention is that of the Swedish State Railways (Kungl. Järnvägstyrelsen) who for some time now, with a view to improving the running qualities of the old four-wheel vehicles, have combined these in pairs to form double articulated cars with a Jacob bogie at the point of articulation. Recently, the Swedish Railways have gone a step further by combining four of these cars to form one unit supported, at the articulations, on three Jacob bogies and at the ends, on two isolated axles. The

(1) The triple semi-articulated rail motor cars of the type 2 — 1 + 1 — B + 1 — 2, series 501, of the electrified mountain sections in German Silesia, the region between Dresden and Breslau, may be placed in the same category (see *Elektrische Bahnen*, Berlin, November, 1929, pages 337-338).

(2) See *Electric Railway Journal*, 23 August 1924, pages 269 to 274.

Fig. 5. — Triple articulated rail motor car with suspended central part, for the Leipzig suburbs.

Printing block : The Birmingham Railway Carriage & Waggon Co. Ltd.

Fig. 6 — Double articulated steam rail car, Duplex type, of the Egyptian State Railways.

running qualities of the vehicles so constructed are said to be excellent.

At the outset, it was stated that the article was intended in connection with the three points referred to under 1, 2 and 3, and which we shall now proceed to consider in what follows.

Reducing the tare with a view to a reduction in the dead weight per unit of useful load carried.

It is the writer's opinion that, generally speaking, an endeavour must be made to reduce the tare of rolling stock by combining the possibilities of using light metals [1] with principles of constructional arrangement aiming at a reduction in the weight of the rolling stock. The most interesting of these principles aiming at a reduction in the weight is undoubtedly the use of articulated cars, of which the particular advantages and respective relationships were mentioned under *a*) and *b*) on pages 705 and 706.

Another possible method of reducing the dead weight by the application of special construction consists in replacing, if the load per axle permits, a four-wheel bogie by a radial axle and we thus come to point 2 of the summary.

The writer will take this opportunity of calling to mind the enormous ad-

Photograph : Swiss Wagon Works, Schlieren-Zurich.

Fig. 7. — Double car of the suburban trains of the Federal Swiss Railways. Compare this figure with figure 8, (cars with radial axles).

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(1) See the paper presented by the author at the VIth International Congress of Mining, Metallurgy and Applied Geology at Liége, 1930, « Les alliages de l'aluminium et leurs possibilités d'application dans la construction du matériel roulant des chemins de fer, des tramways et des autobus » (The alloys of aluminium and the possibilities of their application in the construction of railway and tramway rolling stock and of motor buses). See also *Revue Universelle des Transports et des Communications*, Pontoise-Paris, vol. VI, No. 110, pages 65-84.

vantage of reducing the weight of the rolling stock when it is a question of suburban services where rapid acceleration on starting and stopping of the train over a very short distance are always a necessity in the operation of such services.

Radial axles, as compared with bogies, possess all the advantages which the use of a single axle instead of two has to offer, a point we have already touched upon, especially from the point of view of the non-suspended weight. In addition, the radial axle has the same advantage as four-wheel bogies from the point of view of satisfactory behaviour when runnning through a curve. It is also clear that radial axles, as compared with four-wheel bogies, may likewise possess certain disadvantages, but of course, we are only considering those of radial axle systems. There are such systems which have shown by their construction and by their prolonged use in service, that the radial action of these axles is absolutely perfect. This is very important and should be considered not only at all speeds which may occur, but also, which is a much more important point, for low speeds and with radial axles situated at the front or rear of a train. The writer believes that, for heavy traction, it will be generally preferable to provide four-wheel bogies at the ends of an articulated formation, and if the case arises, to replace the intermediate axles or bogies by radial axles. It is also evident that cases may differ very much according to the running conditions involved on the various railways.

It may be of interest to mention at this point the recent trial of the application of radial axles to two cars having two axles each for the suburban service of a main line. This is the service on the line from Milan to Saronno and beyond of the Milan North Railways (Ferrovie Nord Milano-FNM). On two of the class C 251 coaches (see fig. 8) the fixed normal axles have been replaced by radial axles constructed under the Liechty patent. At the same time the coaches have been connected by a short semi-permanent coupling, allowing the provision of connecting and buffering in keeping with the special construction of these single axle « bogies ». The radial axles and short coupling are indicated by arrows in figure 8. Without desiring to describe here this device, on which articles have appeared in various reviews and which will be dealt with specially in an early number of the English edition of this *Bulletin*, it may be stated that these altered cars have been in service for about a year and have proved thoroughly successful. The author was present during running tests which took place on 12th January, 1931 on the line from Saronno to Lomazzo. In the course of these tests, comparative measurements were made of the oscillations in the different directions, on converted cars marked *a a* in figure 8, on an ordinary two-axle car marked *b* and also on another ordinary bogie car marked *c*, all of which had been placed in the same test train hauled by a steam locomotive of the type 4-6-0 tender express engine. The maximum speeds attained during these runs varied between 65 and 70 km./h. (40 1/2—43 1/2 miles per hour) and the diagrams obtained confirmed the impression that there were fewer shocks on the radial axle cars than on the others when running through curves. In addition, it could readily be seen that, after about eight months' uninterrupted working, there was very slight wear of the tyres and particularly of the wheel flange,

Fig. 8. — Cars with radial axles (*a*) of the Ferrovie Nord Milano; trial train.

whith clearly proves that the axles assume a radial position with respect to the curve when running, and also makes it possible to conclude that there would be a reduction in the operating expenses for the maintenance of the rolling stock and the permanent way.

Finally, in connection with what has gone before, the question of the possible *coefficient of adhesion* and its variation will now be discussed. We know that the coefficient of adhesion normally varies between fairly wide limits, which may be fixed for example between 1 : 4 and 1 : 7. In extreme cases, this coefficient may even vary within a much wider margin in both directions. We also know that the coefficient of adhesion depends upon a large number of factors, and above all varies according to the temporary state of the track at the point in question. Admitting a certain neces-

sary adhesive weight for a railway and for given conditions, this adhesive weight will obviously be based on a definite admitted average coefficient, and it is clear that if the coefficient of adhesion at the unfavourable places can be improved artificially, it will be possible to admit a higher average coefficient. The method most generally employed for improving the adhesion is by sanding which is done by the operation of sand boxes to project sand under the driving wheels. The sand boxes do not always function satisfactorily, however, and are often very much affected by the weather, dampness, cold, etc. Also, the sudden sanding of skidding wheels may produce considerable stresses, incurring the risk of damaging the parts of the locomotive. There exists a rail cleaning appliance, the Bertschmann appliance, which is fixed in front of the first driving axle, and which at the same time slightly sands the rail. This has already been referred to during the discussions of the International Railway Congress Association at Madrid in May, 1931 (1). Its description would take us far beyond the scope of this article, and it will be mentioned merely that in its manipulation, service and maintenance it is still simpler than a sand box, and is also cheap. Moreover, its efficacy is sufficiently good to allow a coefficient of adhesion of about 20 % greater or even more, to be depended on, the latter thus being increased, for example, from 1 : 5 to 1 : 4.

In addition to the fact that, in these extreme cases demanding an exceptionally good adhesion, it is always possible to provide for the whole of the axles to be driving axles, or also in certain cases to increase the adhesive weight for starting (for example, by a « booster » on the back carrying axle of steam locomotives), there is another means of increasing the effect of the adhesive weight, which is, moreover, an invention recently applied in America. Quite recently, the Westinghouse Brake Company carried out trials at Pittsburgh, Pa., U. S. A., in the presence of a large number of experts on electric traction, on a device, also called a « booster », similar to the electromagnetic track brake frequently employed on secondary railways or tramways having steep gradients. This electromagnetic appliance, which is actuated by compressed air, does not descend to make contact with the rail, as in braking, but is maintained at a height of about 15 or 16 mm. (5/8 inch) and by electro-magnetic attraction, against the rail, increases the effect of the adhesive weight. This effect may actually be equivalent to an increase of 20 to 30 % of the load bearing on the driving axles. The same device, still actuated by the current of the contact line, can obviously be employed equally well for increasing the braking effect, while rendering the braking more flexible. The trials showed that the length of run before stopping on sudden braking can be reduced by half by the operation of this appliance. It is clear that, if, as everything leads one to believe, it is possible to construct such an appliance capable of being used in ordinary conditions of railway operation, the adhesive weight required for rail motor cars could be decreased to some extent, and hence the dead weight carried could also be reduced. The in-

(1) See the number of the *Bulletin of the Railway Congress* for August 1930 page 1849. Compare also with what was said by the author on page 1623, June 1930 number of this *Bulletin*.

Fig. 9. — Unit composed of a rail motor car and one trailer (1924 pattern) of the Batavia electric suburban service (State Railways of the Dutch East Indies).

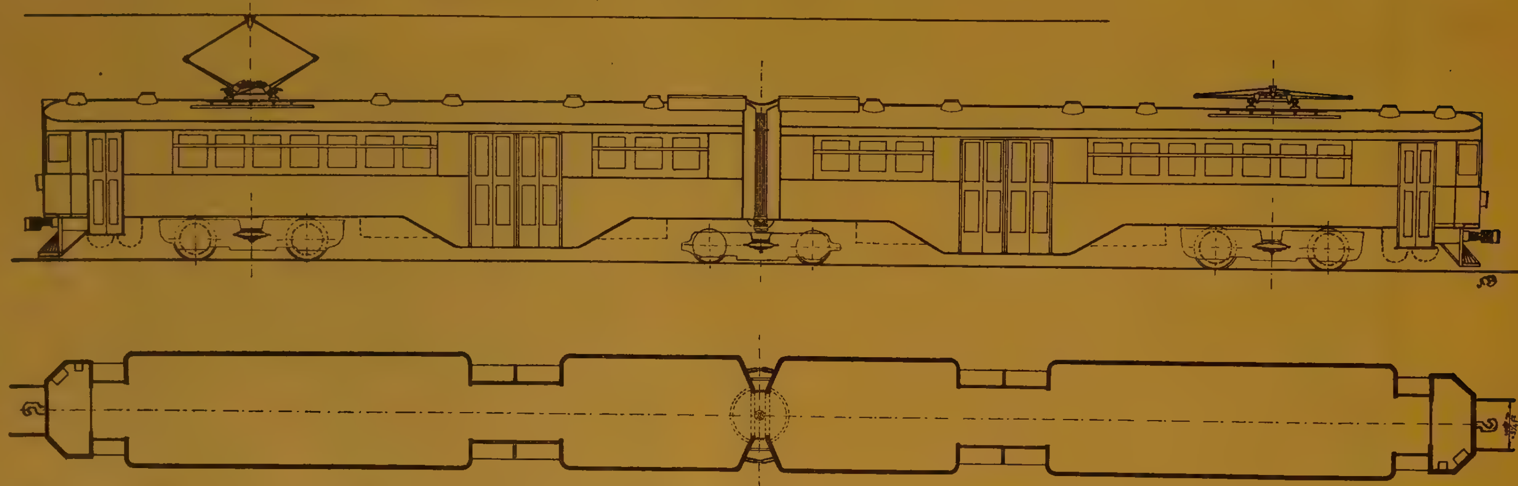

Fig. 10. Design of double articulated rail motor car with three bogies, two of which are driving bogies for the same conditions of service as the unit shown in figure 9. (This design is reproduced on a larger scale than the drawing shown in figure 9; compare the respective overall lengths in the comparative table).

terest in this question is obviously considerable [1].

As to the disadvantages of articulated trains, principally as regards rail motor car trains or trains including driving axles in their composition, objection may be raised that, in case of damage or trouble, the entire train is put out of service, unless spare bogies or driving axles are provided or other readily interchangeable parts are kept in readiness. The question of periodical inspection is less important, since the same number of individual rail motor cars may be inspected simultaneously. It will thus be seen that these disadvantages are relatively small. Mention has already been made at the outset of the disadvantages resulting from the use of articulated trains on main lines, and this is all the more so when international traffic is concerned, but it is believed that the advantage of articulated trains for suburban services has been clearly shown.

To conclude, a comparison will be made for a well determined case regarding a railway on which the author was employed as chief engineer of the electric traction rolling stock. The comparison will be drawn between electric motor car « units » (rail motor cars and trailers) of the suburban services of Batavia of the Dutch East Indies State Railways (Staatsspoorwegen-SS) [2], with articulated trains, a double articulated rail motor car having three bogies (the two outer bogies of which alone would be provided with motors), being intended to replace one « unit » composed of a rail motor car and trailer. The comparison is based on the same passenger carrying capacity (based on the available area), sitting and standing places. The new train being necessarily lighter results in a reduction in the power required for the same running conditions. Without repeating again the advantages of principle mentioned at the beginning (pages 705-706) and to which reference may be made, we shall merely record the data in the table hereafter, while comparing figures 9 and 10.

Independent of the general advantages previously mentioned, the following may be given as the other particular advantages of this comparison :

I. It being possible to provide wider doors without reducing the available space, the length of stops in the stations may be shortened due to a more rapid exchange of the passenger traffic.

II. The power required for the same running conditions, as previously mentioned, is less, on account of the smaller weight of the train. Consequently, less mass to accelerate and saving in electric power.

III. Saving in the maintenance of the brake gear and shoes due to the smaller mass to be braked and to a braking action which is obviously better on a single articulated car than on two cars connected together by ordinary coupling.

It is clear that some of these advantages may be increased considerably by a still greater reduction in the weight of the trains, for example, by the use of light alloys. This would make itself felt

(1) Regarding these various questions, see also the paper published by the author in No. 40 (November-December 1930) of the *Revue de l'Aluminium*, Paris, entitled : « Des possibilités d'allègement du matériel roulant sur voies ferrées » (The possibilities of reducing the weight of railway rolling stock).

(2) See ***Bulletin de la Société Belge des Ingénieurs et des Industriels***, Brussels, No. 2, 1929, pages 135 and 150-152; ***Elektrische Bahnen***, Berlin, September, 1929, pp. 292-294 and October, 1929, pp. 317-319; ***Revue Générale des Chemins de fer***, Paris, May, 1928, pp. 375-380; ***De Ingenieur***, Utrecht, 28 January and 17 March, 1928, pp. 29-47.

	Actual effective data for a unit in service (rail motor car-trailer), as shown in figure 9.	Data calculated for a proposed double articulated rail motor car for the same service, same carrying capacity and the same constructional materials, as shown in figure 10.
Number of available places (seated and standing), approximate	190/230	190/230
Overall length (between the ends of the coach bodies)	34 m. (111 ft. 6 in.)	30.9 m. (101 ft. 4 5/8 in.).
Number of driving axles	4	4
Number of carrying axles.	4	2
Total number of axles	8	6
Tare of train in metric (in English) tons. .	70 (68.9)	61 (60)
H. P. required (hourly average)	470	400
Proportion of useful load to tare [reckoned at the rate of 70 kgr. (154 lb.) per passenger]	$\frac{1}{5.3}$ / $\frac{1}{4.4}$	$\frac{1}{4.6}$ / $\frac{1}{3.8}$
Weight per passenger (assuming the train full) in kgr. (in lb.), approximately . . .	440/375 (970/827)	390/350 (859/772)
Non-suspended weight in metric (in English) tons, approximately	11 (10.8)	8.5 (8.37)
Number of doors (not counting end doors). .	10	8
Number of driver's cabs with complete equipment.	3	2

in a large measure on points II and III, all the more so since a well-defined suburban service is concerned. If, instead of making these advantages tend towards an economy in the maintenance costs, it is desired to make use of them with a view to improving the services, either excess power may be employed or the weight may be reduced with a view, for example, to a greater acceleration on starting and a reduction of the stopping distances, or the power saved may be employed in putting into service a larger number of trains. All these questions are obviously closely interconnected and it rests with each undertaking to see that they are used for best for its particular conditions.

[621. 131 .2]

The "3-30" – The next locomotive (?),

by S. S.

Figs. 1 to 3, pp. 721 to 726.

(*The Railway Engineer.*)

The fact that the maximum starting tractive effort of any locomotive is limited by its adhesive weight, combined with the necessity of its having to be self-starting under load, has made imperative the use of at least two cylinders having a combined volume so restricted by the fact that a long cut-off is necessary to ensure a satisfactory start, that otherwise obtainable power and economy during running have had to be sacrificed. The discovery of the simple positive means described below, for ensuring the prompt starting of locomotives having any desired shortened maximum cut-off, has made practical the use of greatly increased relative cylinder volume with all the attendant benefits.

The writer has made considerable research along these lines, the idea being to determine which combination of large cylinder volume and short maximum cut-off is likely to prove the most practical, and to evaluate approximately the possible economies which might be obtained. The results led to the origination of the cylinder arrangement hereinafter described. The conclusions herewith briefly laid before the railway world for the first time, are put forward with the idea of providing a jumping-off point for the interested designer, rather than a best possible set of proportions. They are offered with the very confident belief that within the principles involved lie the essential characteristics of the next locomotive.

The term « 3-30 » (three-thirty), freely used in what follows, means a single-expansion locomotive with three similar cylinders having a maximum cut-off in the region of 30 % stroke, and bore and stroke dimensions substantially the same as would be used if only two cylinders were to be employed in the usual manner. The mean starting tractive force exerted by the 3-30 engine described is calculated to be substantially the same as that put out by a conventional one having two cylinders of like dimensions and a maximum cut-off of about the usual 85 % stroke.

There, however, the similarity of performance ends, and it is felt that the advantages of the 3-30 arrangement may be best visualised if considered in comparison with such a two-cylinder counterpart as is here given. Hereinafter such engine will be termed the « 2-85 ». The purposes of this article may, perhaps, best be served if the suggested advantages of the proposed arrangement be dealt with under three separate headings, viz. :

1. Those derived by use of the three-cylinder principle.

2. Those resulting directly from short cut-off operation.

3. Those peculiar to employing a short *maximum* cut-off.

Considered in this order, we have :

1. *The advantages of the three-cylinder principle.* — The benefits to be derived by employing three simple cylinders instead of the ordinary two have been enumerated in many excellent papers by prominent locomotive engineers and designers read before such representative bodies as the Institution of Locomo-

tive Engineers, the Institution of Mechanical Engineers, and the Stephenson Locomotive Society of England; the American Society of Mechanical Engineers, and various Railroad Clubs of the U. S. A. and in other countries; also, admirable articles have appeared in the technical Press during the last few years, both at home and abroad, all seeming to agree that the advantages include more weight per driving axle and faster running due to better balancing; improved steaming abilities due to the six exhausts; lower coal consumption rates; and less loss of heat through superheater. Consequently it would be superfluous here to more than point to the very significant fact that each of the four great railway systems of England have incorporated in their latest express passenger locomotives, designs employing the multi-cylinder principle, two companies favouring the three-cylinder arrangement, one the four-cylinder and one examples of both.

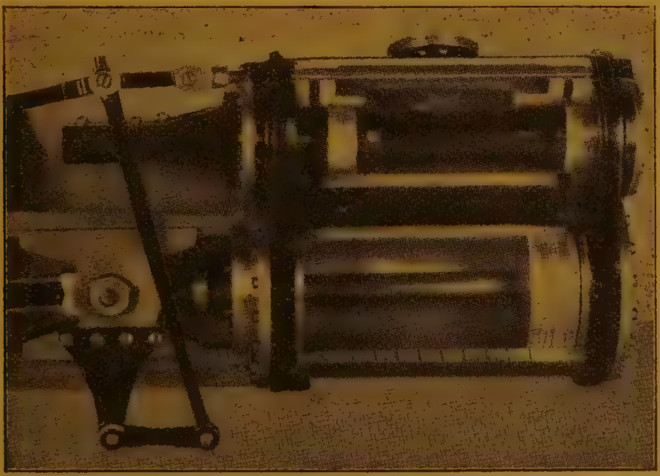

Fig. 1. — Section through cylinder casting for "3-30" locomotive.

2. *Advantages of short cut-off operation.* — That economy demands high initial pressure and a maximum expansion has, of course, been known since the time of Watt, and attempts to obtain the full benefit of that knowledge by using a short cut-off have been materially advanced by the introduction of the superheater, but the varied conditions under which the locomotive has to operate has hitherto prevented obtaining that high degree of economy now possible with the stationary engine. Just what measure of economy can be realised and the goal to be strived for by designers may be gathered from the published results of tests of a *Pacific* type engine by the Pennsylvania Railroad Company, to whom indebtedness is acknowledged for the following quotations from their Bulletin No. 29, (page 54): « If, however, by cylinder enlargement, the maximum power of the locomotive (3184 I. H. P.) were to be developped at 15 % cut-off instead of at 65 %, there appears possible the reduction of coal used by an amount equal to the difference between 1.52 and 3.71 lb., a saving of 2.19 lb. per I. H. P.-hour, or 59 %. » As to steam consumption, there appears on page 56 : « Where the consumption is considered on the basis of cut-off, we find

that at speeds above 240 r.p.m. a cut-off of about 15 % gives the best results. At lower speeds cut-offs of from 25 to 35 % appear more advantageous. This, however, does not apply to the coal consumption, as on that basis 15 % cut-off seems to be the best at all speeds, as has been noted. » Again, on page 57 : « At the lower and medium speeds the best steam rate is found at about 30 % cut-off. At high speeds the best rates are found at cut-offs shorter than 30 %. » Regarding superheat effect on short cut-off, we read on page 63 : « At any cut-off there is a saving in steam by an increase of superheat. This saving is more marked at short than at long cut-offs. » Data are given whereby it is seen that it requires 180° of superheat to give the same steam rate at 55 % cut-off which 105° produces at 25 % cut-off, and that a superheat of 230° at 55 % cut-off, an increase of 50°, effects, in consequence of that additional 50°, a saving of only 3 1/2 %, whereas the same additional superheat to the 105 mentioned at 25 % cut-off effects a steam saving of 18 1/2 %.

As to cylinder back pressure; a speed of 360 r.p.m. — more than diameter speed — was required to register 5 lb. at 25 % cut-off, whereas 12 lb. was shown at 55 % cut-off at a speed of only 160 r.p.m. Regarding machine efficiency, on page 77 is found : « There is in general a decrease in machine efficiency with increase in speed; however, this is not so marked as it is with decrease of cut-off. At short cut-offs, 15 %, the machine efficiency in fact is comparatively constant between 120 and 360 r.p.m., while at 25 % cut-off there is apparently a slight decrease. » Concerning thermal efficiency we find on page 79 : « The best and second-best results... were obtained at 15 % cut-off, while the efficiencies next in order are... all at 35 % cut-off. Study of the data shows that the minimum of thermal efficiency in any of the tests at any speed was obtained at the maximum limit of cut-off, that is, at the maximum of power. » And in conclusion, on page 81, we read : « Considering the possibilities of economy with superheated steam, by a more complete expansion than has been customary, these test results show that there is a very substantial saving to be obtained by the use of cylinders of large volume, with which a short cut-off would develop the maximum power. » The tests, from the results of which the above extracts were taken, were made in what is probably the finest test plant for locomotives in the world, and referred to a very successful locomotive of which a great many were built. They were published many years ago and are doubtless recalled by many, yet it was felt that these few quotations from so particularly interesting a report would bear repetition here in consequence of their very significant bearing on the subject in hand, and particularly on that which now follows.

3. *Advantages peculiar to the use of a short maximum cut-off.* — It is here recalled that the locomotive which was the subject of tests just referred to was of the usual long cut-off class, one inherent disadvantage possessed by which being that of restricted port openings at the shorter cut-offs. The serious effect of small port openings is fully dealt with by Mr. E. L. Diamond in his Paper read before the Institution of Mechanical Engineers, and from which the following quotation is made. « In the cylinders of the locomotive under investigation, which is known to be of high efficiency, the total losses due to the restricted passages given to the steam at admission and exhaust increase from 17.6 % at 24 m.p.h. to no less than 67.6 % at 68 m.p.h., of which probably not more than 15 % is necessary for the production of draught, that is to say, an amount of power equal to half the work that is being actually exerted on the train is wasted on throttling losses at this speed. In view of this fact, the universal adoption of the long lap valve is unhesitatingly recommended by the author. In cylinder design the

use of long direct ports and a free exhaust passage should be the first requirement. It has long been vaguely known that this is desirable, but it has probably not been realised what an enormous effect on the engine's performance insufficient attention to these points must inevitably have. » Realising that an increase of maximum valve travel of about 50 % is required to improve the steam port opening one-eighth of an inch when cutting off at 30 % and that link length and swing are now at about the practical limit, it is seen that designers are virtually helpless.

Where the 3-30 locomotive is concerned, however, that trouble is completely non-existent, for it will be found that if we change the maximum cut-off of an existing engine from 85 to 30 % the same link, swinging through the same arc as now, not only permits increasing the maximum travel by 40 %, but the port opening at 30 % cut-off has been increased by no less than 150 % : that is, the maximum travel which was, say,

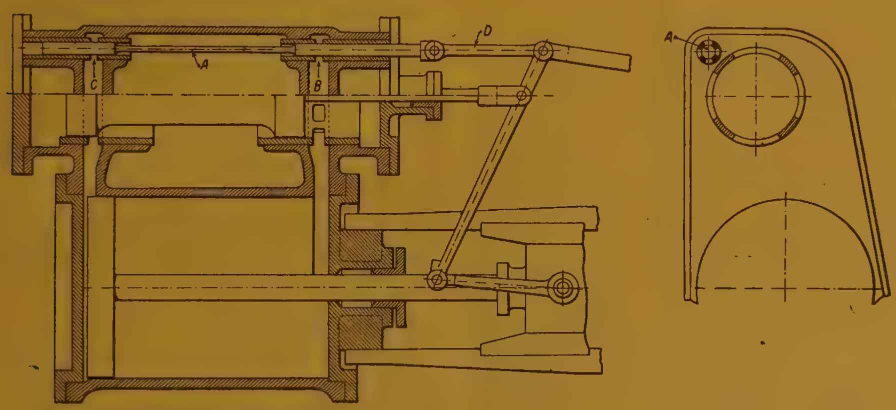

Fig. 2. — Details of cylinder, steam chest and valve gear arrangement for " 3-30 " locomotive.

6 1/4 inches, now becomes 8 3/4 inches, and the 30 % cut-off port opening of about 0.37 now swells to substantially 15/16 inches, so constituting a limit which should satisfy most designers. The writer, however, takes the view that the inertia forces set up by such a travel at high speed would be prohibitive, although the valve could perhaps bear considerable reduction in diameter and, therefore, weight, and notwithstanding also the fact that the upper end of the combination lever has been lengthened over 125 %, so bringing on the link gearing a smaller percentage of those forces than formerly. Indications are that the best maximum valve travel for all-round purposes is that which would also have been the maximum had 85 % been the maximum cut-off, or slightly less. If, then, when converting the imaginary 2-85 engine to 3-30 form the same amount of maximum valve travel be used and the parts changed to suit, it will be found that the present link swing must be reduced 40 to 45 %, thus reducing link block slip, which, with the whole half-link available for cut-offs from zero to 30 % making fine valve-setting and adjustment possible, means in itself a distinct improvement. Exactly how the valve will behave is shown in Table A,

which has been compiled for the purpose of easily comparing the valve events of the 2-85 engine with those of the 3-30. No account has been taken of the effects of rod angularity; all figures are averages and may safely be used for comparison, for variation of the actual from the figured, though small, will of course apply to both the 2-85 and the 3-30 engines.

It has been assumed that not only are the cylinders of the two engines of the same bore and stroke, but that the valves are of the same diameter also, the width of the opening therefore being a true comparison of areas. The real value of an opening is, however, the mean area times the length of time it is open. This value is denoted above by the term « Degree-Inches », and is made up of the product of the mean opening and the number of degrees passed through by the crank between the opening and the closing points of the valve. It is felt to be superfluous here to give data of the 2-85 at any cut-off greater than 50 %. Many features of interest may be brought out by assuming a speed and comparing the characteristics of the two valve actions with various cut-off combinations, the value of which may be enhanced by then constructing probable indicator cards for comparison of M.E.P., steam consumption, back pressure and the construction of torque curves. For instance, comparison of 2-85 (50 %) with 3-30 (30 %) any speed.

Steam ports. — The 3-30 engine has a 1 1/2 % better maximum opening and 5 1/2 % greater mean opening. In degree-inches, the 2-85 has a 28 % larger value, but, assuming compression pressure to equal one-half the initial pressure, and also a 10 % clearance volume, the 2-85 has to fill a volume equal to 55 % of the volume swept out by the piston, against but 35 % in the case of the 3-30; therefore the 3-30 has a 22 % better opening per unit of volume to fill, which percentage rises as the assumed compression pressure arises. This, together with the fact that the piston speed is less at 30 % than at 50 % stroke, indicates that the cut-off pressure of the 3-30 engine at any speed should be appreciably higher than that of the 2-85 at even 50 % cut-off.

Exhaust ports. — The 3-30 engine has 56 % larger mean opening and 20 % greater degree-inches value than the 2-85. This exhaust superiority together with the lower release pressure, should so reduce the back pressure of the 3-30 that the effects of the increased compression period will be nullified. Probable indicator cards laid out for various speeds seem substantially to agree that at any given running speed the united M.E.P. of the 3-30 engine will be about 30 % higher than that of the 2-85, whereas the steam required by each engine appears about equal. The 3-30, therefore, may very confidently be expected to draw a substantially increased load at the same steam rate or the same load as the 2-85 on considerably less steam.

It seems to be generally felt that three coupled axles are all which can be deemed desirable on fast passenger service; if the wheel load limit is also reached, then the D.B.P. at speed limits the possible tonnage for one engine on that railway. From that which has gone before it is now obvious that the 3-30 engine permits an increase of tonnage in this service up to at least 50 and perhaps 60 % for the same weight on the drivers, provided sufficient additional evaporative power be supplied, which itself should not be difficult for the 4-6-0 type engine, additional supporting means for the larger boiler taking the shape of one or two pairs of carrying wheels under the firebox. With this change in view, compare the valve events of the 3-30 and the 2-85 engines, both at 30 % cut off.

Table A.

Locomotive type	2-85			3-30		
Maximum valve travel, inches	6 1/4			6 1/4		
Lap	1 1/16			2 1/2		
Lead	1/4			1/4		
Ex. clearance	1/8			0		
Ex. lap	0			5/8		
Cut-off, per cent	50	30	25	30	25	20
Valve travel, inches	3.376	2.88	2.79	6.25	6 082	5.89
Lead angle	11	18	20.5	8.5	9.5	11
Max. steam port opening, inch	0.615	0.377	0.333	0.625	0.541	0.477
Mean steam port opening, inch	0.414	0.255	0.225	0.437	0.372	0.312
Degree-inches	42.2	21.6	18.15	32.8	25 8	20
Release, per cent	79	67	63	82	80	77.5
Max. exhaust port opening, inches	1.625	1.565	1.52	2.5	2.42	2.32
Mean exhaust port opening, inches	1.02	0.99	0.95	1.59	1.55	1.5
Degree-inches	209	187	181.5	250	243	233
Compression, per cent	16	25	29.5	35.5	38	42

Steam ports. — The suggested 3-30 locomotive has a 66 % larger maximum opening, and 71 % greater mean opening, its degree-inches advantage being 52 %; in consequence the cut-off pressure should be much higher, which, together with the later release — 82 % instead of 67 % — will raise quite appreciably the steam line of the card at any speed.

Exhaust ports. — The 3-30 engine has a 60 % larger mean opening and its degree-inches value is nearly 34 % greater, consequently no difficulty is anticipated exhausting the larger amount of steam admitted, to a back pressure sufficiently lower than the 2-85 to compensate easily for the 10.4 % additional compression period of the 3-30 engine.

Where steam saving only is to be considered, compare the 2-85 at 30 % cut-off with the 3-30 engine at 20 % cut-off and note the difference in M. E. P. or the 2-85 engine at 50 % and the 3-30 at 25 % cut-off.

The above is believed to be thoroughly feasible, the only debatable point being just how much exhaust lap to use, and actual test may be required to determine this : more will, of course, be necessary on shunting than on express passenger work, where an otherwise undesirable drop at the toe of the card at starting might be excusable in view of the benefits generally obtained. The same lead has been assumed, but in view of the difference in lead angle it may bear increasing on the 3-30 engine for fast service.

Finally, as the 3-30 engine could not always start itself under load unaided, starting means must be provided. In figure 2 is seen the writer's idea of a simple, fool-proof, rugged, positive-acting device, consisting, as seen, of but two moving parts per cylinder, each of plain one-piece construction, while its weight, maintenance and power required for operation are entirely negligible; it is operated preferably by the valve-gear as shown, in which case it will automatically go out of action as the cut-off at the main valve is shortened. It may be incorporated in the cylinder castings or constructed as a cylinder attachment, and lends itself to possibility of one design which may be universally applied to all engines irrespective of size or class. The small valve *A* controls the ports *B* and *C* and is operated by the light connecting link *D* pivoted to the radius rod or combination lever as seen. Connected as shown, *A* operates, of course, at a phase of 90° with the piston, therefore, if *A* be given lap such that it opens at 25 % piston stroke, it will close at 75 %, or, if opening at 20 %, it closes at 80 %, and so

on. Its travel decreases as the main cut-off is shortened, and it finally goes mechanically out of action by failing to uncover the ports at all; for instance, if the 3-30 engine be shortened during running to, say, 25 % cut-off, *A* will then be out of action if suitably proportioned. This relation of going out of action to the shortening of the main valve cut-off may be varied considerably to suit different conditions of service. The co-operating functions of valve *A* and the main valve are clearly shown by the larger of the two valve diagrams, figure 3, whereon the diameter *E-F* represents the main valve

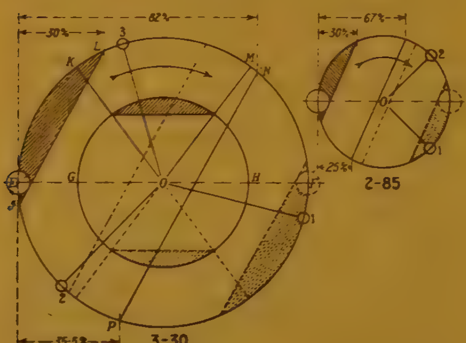

Fig. 3.
Valve diagrams for "3-30" and "2-85" locomotives.

travel, and *G-H* that of the valve *A*. The crank starting from dead centre *E* when the main valve is open to lead steam, moves in the direction of the arrow. When it reaches position *K* valve *A* is seen to be about to open its port, although the main valve does not close until the crank reaches position *L*, the point of cut-off; valve *A* remains open until the crank arrives at position *M* just prior to *N*, the point of release, exhaust taking place from then until the crank reaches *P*, where compression commences, and continues to *J*, the point of main valve admission. The dotted lines refer to the other end of the cylinder. The ports *B* and *C* controlled by valve *A* are very small — about one-half of 1 square inch in area each — consequently they pass but a negligible amount of steam when running even at very slow speed; their purpose is purely to assure starting when the locomotive stops with the cranks in unfavourable positions; for instance, if the engine comes to rest with the cranks occupying the positions marked 1, 2 and 3, obviously only crank 1 is under the influence of steam, for crank 2 is in exhaust position and 3 is past the aid of the main valve; being so near dead centre, the rotative effort of crank 1 is, of course, entirely inadequate to start the load, so valve *A* steps in to assist by supplying steam at this time to the piston operating crank 3, as seen; this steam enters the cylinder at low pressure, due to the wire-drawing effect of the small ports, but builds up in pressure in the cylinder, while the engine still remains unmoved until sufficiently high to start the train; crank 3 remains under the influence of steam until release at *N*, when crank 1 will be in position to carry on until 2 is able, and so on. The mechanical going out of action of valve *A* may be demonstrated thus : as the main cut-off is shortened the travel, *G-H*, of valve *A* decreases also, and the lines *O-K* and *O-M* approach one another as *L* moves back towards *E*: the shortening process continuing, *K* and *M* finally coincide vertically to *G-H*, when, and thereafter, valve *A* fails to uncover its ports. The valve diagram of the 2-85 when also cutting off at 30 % is drawn to the same scale as the 3-30 engine, consequently comparison of port openings may be readily made. Another important feature in favour of the 3-30 is that of minimum starting effort. Assume the cranks of the 3-30 locomotive to be moved backward until 3 is near *L*, then the cranks of both engines are in their respective worst positions for starting; note now the angles of the cranks under steam — 3 and 1 of the 3-30, and 1 of the 2.85 locomotives — at this time the rotative effort of the 2.85 is about 64 % of its mean effort, whereas the 3-30

is at this time exerting a rotative effort substantially equal to its own mean when calculated, neglecting any assistance from valve *A*, and this means, of course, that with the 3-30 engine it will never be necessary to set back to get in more favourable crank position when starting. Furthermore, the auxiliary ports may vary in area also as service may require, such as being made relatively large for the rapid acceleration required for local passenger service, the smaller sizes being more desirable where much slow pulling is done. The valve itself may be almost any size, preferably the same diameter as the main valve stem, so that the same glands and packing may be used. Lubrication of valve *A* is as assured as is that of the main valve.

For experimental, and later for varied service work, the effective area of the auxiliary ports B and *C* may be quickly varied by forming valve *A* partially blind and providing for relative rotative movement between this valve and its sleeves carrying the ports; also endwise adjustment of these sleeves has the effect of varying the laps of valve *A*. This starting device may be used on two and four cylinder engines also; if the latter are arranged similar to the Great Western Railway locomotives, then only two will require valves *A* cross-piping from each to its mating cylinder. On a 3-30 engine it may be left off the center cylinder if not much starting has to be done, for there need be no « blind » spots, only two weak ones of about 40° per revolution, and, standing in one of these positions, reversing the gear produces full power that way; therefore an occasional set-back when starting may justify exclusion of the centre valve *A*. It is particularly interesting to note that the above-mentioned economies and advantages, possible through the use of new valve *A* are *not* effected or produced *by* that valve, but *are all* obtained with precisely the same means, cylinders and valves, as have always been used, and which are operated in exactly the same manner as they always have been operated, for valve *A* merely *permits* the ordinary mechanism to expand itself, as it were, to put forth all the mighty strength which it always has been known to possess, yet has been incapable of exerting prior to the advent of tiny valve *A*.

Summary.

In conclusion, the author suggests that the 3-30 arrangement appears to offer the following advantages : Steam saving of at least 35 % during full gear operation. Improved porting, both admission and exhaust, reducing wire-drawing which, with well-delayed release, makes earlier cut-off operation practical. Maximum tractive effort, minus only the reduced wire-drawing effects referred to, available throughout the entire speed range. Maximum crank-pin pressure the same as 2-85, but lasting only about one-third as long, thence tapering off; therefore less wear and better for lubricating. The same applies to slide bars and rods. Greatly reduced link-swing, effecting less link block slip, less stress on link block supporting parts and easier reversing, making power reversing means unnecessary; better distribution possible. Reduced proportion of valve operating forces carried by the gear; elimination of setting back to get started; no additional responsibility for the driver, nothing more for him to do or look after than in an ordinary three-cylinder locomotive.

MISCELLANEOUS INFORMATION.

[625 .143 .4]

Adapting Z type fishplates for use under modern locomotive axle loads, Buenos Ayres and Pacific Railway.

Fig. 1, p. 728.

On a stretch of main line track (70-lb. flat-bottom rails with Z-type fishplates) it was decided to stone-ballast the track, and to reduce the spacing between joint sleepers from 0.72 m. to 0.54 m. (2 ft. 4 3/8 in. to 1 ft. 9 5/16 in.). This latter is the standard spacing between joint sleepers for 70-lb. rails with 4-hole standard angle fishplates.

On 83 km. (51.6 miles) of the track in question, however, the fishplates were of a Z-type; this type of fishplate was standard for 70-lb. F. F. rails on this railway prior to the introduction of the angle-type fisplate mentioned above, and spacing of 0.72 m. (2 ft. 4 3/8 in.) between joint sleepers was required when they were put in the track.

The Z-type fishplates had not been found to be too satisfactory, however, more especially as locomotive axle loads increased, and distinct « hammering » of rail ends had been

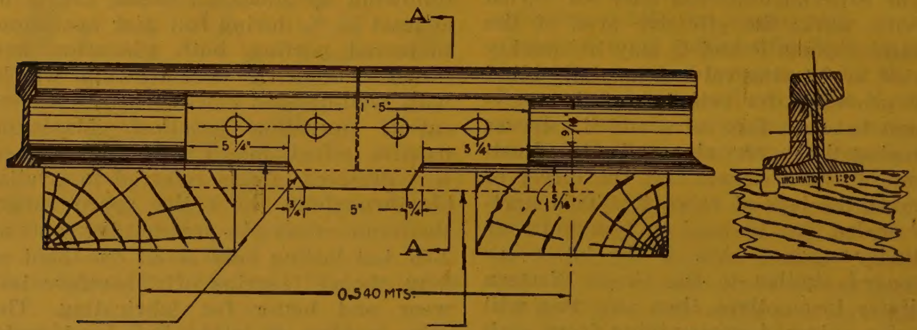

Fig. 1.

noted. Consequently, the angle-type of fishplate had been introduced for all new work.

When however, it was decided to stone-ballast these 118 km. (73.3 miles) of track and to reduce the joint sleeper spacing to 0.54 m. (1 ft. 9 5/16 in.), it was thought, at first, that it would be necessary to buy new angle fishplates for this, *i. e.* some 18 600 pairs would be required. On further consideration, however, it was decided to try out a few pairs of Z-type fishplates cut (by the acetylene flame) to the shape shewn on figure 1.

On trial in the track, it was found that these gave satisfactory results, and the only point remaining to be decided was whether the cutting of the fishplates existing in the track could be done economically. The stock of spare Z-type fishplates was extremely limited, and this complicated the matter somewhat. This problem was tackled however, and a portable acetylene cutting plant, available for use alongside the track, was assembled, together with the simple jigs necessary for ensuring easy and accurate cutting.

Some 100 pairs of Z-type fishplates were cut and held ready for installation in the track, *i. e.* for 1/2 kilometre of track. All plant being in readiness these were bolted into their places and the 100 pairs produced were then run through the machine.

This process was repeated, working in the intervals between trains until the whole of the 83 kilometres had been re-fishplated. Where the existing fishplates were much worn, 1/8 inch thick steel liners were fitted, and the result has been a satisfactory track at a smaller cost. The total saving on these 83 km. (51.6 miles) is estimated at £4 700.

Since that date two further stretches of 35 and 115 km. (21.7 and 71.5 miles) have been dealt with in the same manner and the idea has been extended so as to use up some thousands of pairs of Z-type fishplates which it had been thought imprudent to use on the main line with modern heavy axle loads owing to the « hammer » effect produced. Also, it is learned that another large Argentine railway which had commenced to substitute 4-hole Z-type fishplates by 6-hole angle fishplates drilling the 2 extra holes required in the rails and putting in new angle fishplates, decided to abandon this, and adopt the above method, effecting a very large saving indeed.